Popular Astronomy

Vol. XXXIX, No. 6 JUNE-JULY, 1931 Whole No. 386

ALBERT ABRAHAM MICHELSON

By FOREST R. MOULTON.

On May 9, 1931, in his seventy-ninth year and at the zenith of his fame, Albert Abraham Michelson died. As the news of his death was spread by telegraph and cable, the whole world acclaimed his incomprehensible genius; but his intimate acquaintances mourned and still mourn the loss of a friend who was gentle and wholly without affectation.

No scientist of the present day has had a more romantic life than that of Michelson. As a small child, his parents brought him to the United States from Strelno, Germany, where he was born on December 19, 1852. His school days were spent in San Francisco, California. In 1869, at the age of seventeen years, he made a journey alone across the continent to Washington in order to apply personally to President Grant for an appointment as a Cadet in the U. S. Naval Academy, at Annapolis, Maryland. Since genius has a habit of recognizing its kind, he received the appointment. He graduated in 1873 and became a midshipman in the United States Navy. From 1875 to 1879 inclusive he was an instructor in physics and chemistry in the Naval Academy; in 1880 he served on the staff of the *Nautical Almanac*, in Washington; from 1881 to 1883 he studied in Berlin, Heidelberg, and Paris; he was Professor of Physics in Case School of Applied Science, in Cleveland, Ohio, from 1883 to 1889; from 1889 to 1892 he was a professor in Clark University, in Worcester, Massachusetts; and in 1892 he answered President W. R. Harper's call to join the new adventures in research, scholarship, and education which were then being started on the Midway, in Chicago. Until his retirement in 1927, he was Head of the Department of Physics in the University of Chicago and he was the first Distinguished Service Professor in the University.

Many of the great scientific societies of the world elected Michelson to their membership. Moreover, he received numerous prizes and medals, among which were the Copley medal of the Royal Society and the Nobel prize for physics, in 1927, in each case the first granted to an American. Many universities, both American and foreign, honored themselves by bestowing upon him honorary degrees. He was president of the American Physical Society, in 1901-03; of the American Association for the Advancement of Science, in 1910-11; and of the National Academy of Sciences, in 1923-27.

Dates and lists of honors do not really constitute biography; at the most they form a framework on which may be hung a more or less

adequate picture of an individual. No intimate friend of Michelson ever thought of him in terms of high positions or great honors. To me he was like the sea on a summer's day—serene, illimitable, unfathomable. This was not a superficial impression, for I knew him intimately for more than twenty-five years. On scores of occasions I played tennis with him and against him; on a larger number of occasions I played billiards with him. I accompanied him to tennis championships, to billiard matches, and once we occupied ring side seats at a professional wrestling match. Often we took lunch together; many times I called on him in his simple office in Ryerson Laboratory.

I said that to me Michelson was like a serene sea. He was unhurried and unfretful. He was never rushed by University duties; he never drove himself to complete a laborious task; he never feared that science, the University, or mankind was at a critical turning point; he never trembled on the brink of a great discovery. He gave the impression of the serenity of illimitable breadth and unfathomable depth. Though one had a feeling that the depths on occasion might be disturbed by a storm, I never heard him raise his voice above its accustomed level.

There are doubtless many motives that inspire men to scientific achievements. If I have correctly caught the dominant note of his life, Michelson was moved only by the aesthetic enjoyment his work gave him. In everything he did, whether it was work or play, he was an artist. His co-ordination was so perfect and his touch was so deft that there was more satisfaction in being defeated by him at billiards than in winning from another opponent. I recall with what pleasure Professor Sargent of the Art Department used to watch the gracefulness of his playing. Michelson was an artist also in the more ordinary sense of the word, for he was a skillful amateur performer on the violin and his water colors were a delight. And often at luncheon on the back of a menu card he would sketch the profile of a colleague. But all these expressions of his artistic nature were in private and purely for his own pleasure, and many of his friends were quite unaware that he had these accomplishments.

Michelson's art was also manifested in his experiments, even in the first experiment he performed, that of measuring the velocity of light as a class demonstration, at Annapolis. With his hastily constructed apparatus he secured results of a higher order of accuracy than any that had theretofore been attained. Much of his scientific work throughout his long life related to light, and his last experiment, completed just before his death, was an extraordinarily accurate measurement of its velocity. In all of his experiments he exhibited an uncanny ability to make apparatus work. For example, after French physicists thought they had proved both theoretically and experimentally that interference phenomena could not be secured in white light, he set up in Paris his recently invented interferometer with the materials that happened to be available and astonished the French scientists with its performance. For the purpose of measuring short distances or small angles, the interfer-

ometer is incomparably superior to the microscope. An outgrowth of this early instrument is his later stellar interferometer with which in recent years the diameters of several stars have been measured.

Early in his scientific career, Michelson, in association with E. W. Morley, performed an experiment which marks a turning point in the philosophy of physical science. To the mass of mankind the surface of the earth appears fixed, but to the astronomer the earth is a tiny globe which spins on its axis and revolves about the sun. If one should be tempted to conclude that motion with respect to the sun is absolute, astronomers would inform him that the sun moves with respect to the stars; and recently it has been found that our galaxy is moving with respect to exterior galaxies.

In 1887, Michelson and Morley undertook to measure the motion of the earth, not with respect to the sun, or our galaxy, or exterior galaxies, but with respect to the ether, an assumed all-pervading medium through which light is transmitted and which, if anything, would give absolute motion. The quantity to be determined was so minute that it could be measured only with the aid of Michelson's interferometer. To the astonishment of scientists no certain motion of the earth with respect to the assumed ether was found. Though light has the properties of wave-motion, it appears to be propagated with a speed which is independent of the motion of its source.

Einstein's theory of relativity has its roots in the Michelson-Morley experiment. All the changes in point of view it has introduced into physics and astronomy rest upon the experiment carried out in Cleveland in 1887, and upon the subsequent verification of its surprising results. Whatever modifications the theory of relativity may undergo, and whatever may be its ultimate fate, the results of the Michelson-Morley experiment stand.

In 1913, Michelson and Gale carried out their first earth-tide experiment, the purpose of which was to determine the degree of rigidity and of elasticity of the earth. Sir George Darwin had built up a beautiful theory of the tidal evolution of the earth-moon system, including the separation of the moon from the earth by fission, on the hypothesis that the earth as a whole is a viscous body. A number of us in 1909 had concluded from dynamical and geophysical considerations that the theory of tidal evolution is quantitatively erroneous. The tide experiment and the associated laborious mathematical work were undertaken coöperatively for the purpose of testing the basic hypothesis of the tidal theory. As scientists generally know, it was found that the earth on the whole is as stiff and as elastic as steel.

The brilliancy of Michelson as an experimenter is well illustrated by the tide experiment. Although the radius of the earth is uncertain by several hundred feet, he measured the variations it undergoes as a consequence of the tidal forces of the moon and the sun to within one-hundredth of an inch. The final series of measurements, extending

throughout all of 1917, were automatically recorded on motion picture film by the aid of his interferometer.

Another adaptation of the interferometer led to a means of measuring the diameters of minute satellites and planetoids and of the larger of the stars. It is applicable also to measuring the distances between the components of double stars which are so close together as to be completely inseparable by the most powerful telescopes.

Although Michelson's work has had an enormous influence on science and will be referred to as basic for generations to come, he published a relatively small number of papers and books, only about 75 in all. He never rushed into print with immature work. He was not in the habit of publishing the same thing over and over again in slightly varying form. He did not run around the country, posing as a genius and addressing minor scientific organizations. He never invited the press to carefully timed dramatic announcements before the major scientific societies. He never proclaimed the explosion of the Universe. He never attracted popular attention and approval by claiming to find support for theological dogmas or the doctrine of the freedom of the will in the laws of falling bodies or in any other scientific principles. Instead, he pursued his modest and serene way along the frontiers of science, entering new pathways and ascending to unattained heights as leisurely and as easily as though he were taking an evening stroll.

THE MECHANICS OF THE TELESCOPE

By E. P. BURRELL.*

In order to present a background for this subject, it seems desirable to sketch briefly the history of the telescope. The discovery of the telescope is a much discussed question, the conclusion according to the *Encyclopedia Britannica* being that Hans Lippershey, a spectacle maker of Holland, was the first person who independently invented the telescope and at the same time made the instrument known to the world.

Telescopes seem to have been made in Holland in considerable numbers soon after the date of their invention, and rapidly found their way over Europe. But the honors must be shared with the Italian philosopher Galileo, who in May, 1609, made his first telescope by fitting a convex lens in one extremity of a leaden tube and a concave lens in the other one. He presented the instrument itself to the doge Leonard Donato, sitting in full council. The senate, in return, settled him for life in his lectureship at Padua and doubled his salary. Galileo may thus claim to have invented the telescope independently, but not until he had heard that others had done so. It is certain that he was the first to apply the principle of the telescope to astronomical research.

*Director of Engineering, The Warner & Swasey Company, Cleveland, Ohio.

By the middle of the seventeenth century, several makers of lenses had so far improved the methods of grinding and polishing, that telescopes notably superior to that of Galileo were procurable. The Dutch philosopher Huygens developed telescopes varying in length from 150 to 200 feet. With one of these in 1655 he discovered the largest satellite of Saturn, thus adding a fifth member to the list of planetary bodies known to the ancients. But his most important astronomical discovery, made also in 1655, was the nature of the rings of Saturn.

To Sir Isaac Newton belongs credit for the discovery of the reflecting telescope. When in 1666 he made his discovery of the different refrangibility of light of different colors, he soon perceived that the faults of the refracting telescope were due much more to this cause than to the spherical figure of the lenses. Newton's first telescope so far realized his expectations that he could see with its aid the satellites of Jupiter and the horns of Venus. Encouraged by this success, he made a second telescope of 6⅓ inches focal length, with a magnifying power of 38 diameters, which he presented to the Royal Society of London in December, 1671. A third form of reflecting telescope was devised in 1672 by Cassegrain. No further practical advance appears to have been made in the design or construction of the instrument until the year 1723, when John Hadley (best known as the inventor of the sextant) presented to the Royal Society a reflecting telescope of the Newtonian construction, with a metallic speculum of 6 inches aperture and 62⅝ inches focal length, having eyepieces magnifying up to 230 diameters.

In 1755, the English optician John Dollond discovered that the dispersion of light was variable when refracted through different kinds of glass. With this fact as a key, he constructed object glasses having two lenses of such form and refracting power that one would correct the error of the other, and thus eliminate entirely the spherical aberration as well as the greater part of the chromatic aberration. This invention removed in a very large measure the difficulty which for one hundred and fifty years had been a check to progress in the use of refracting telescopes. Credit is given to Chester Moore Hall, of Essex, England, for having made the first achromatic objective, in the year 1733; but the theoretical as well as the practical development of this great invention is certainly due to John Dollond.

About the year 1774 William Herschel, then a teacher of music in Bath, began to occupy his leisure hours with the construction of specula, and finally devoted himself entirely to their construction and use. In 1789 he completed his reflector of 4 feet aperture and 40 feet focal length. The reflecting telescope became the only available tool of the astronomer when great light grasp was requisite, as the difficulty of procuring discs of glass (especially of flint glass) of suitable purity and homogeneity limited the dimensions of the achromatic telescope.

Each advance in the optical efficiency of the telescope necessitated equal improvement in mechanical means for adjusting and using the instrument. At first it was simply held in the hand, and even as crude

methods of support came gradually into vogue, they were of small use otherwise than as approximately holding the tube in position. Previous to the eighteenth century the best telescopes were used with the alt-azimuth mounting, having as the name indicates, one motion in altitude and one in azimuth, the combination of these motions enabling the observer to point the instrument to any part of the visible heavens. The apparent motion of the stars made the use of this type of mounting very unsatisfactory and inadequate for observing, especially when high magnifying powers were required.

We do not seem to find any mention of the equatorial telescope until Roemer, the Astronomer Royal of Denmark, made one early in the eighteenth century and we may believe he was the original inventor of this most excellent type of mounting which has become standard throughout the world.

Each generation has seen larger and still larger telescopes projected and finally built, as the development of the Mechanic Arts has made the greater enterprise practicable. This is naturally the case, for the astronomical telescope is essentially a mechanical device. It includes optical parts which must, of course, receive careful attention in their design and manufacture, for the usefulness of the instrument approaches a maximum only as its construction approaches both optical and mechanical perfection, but, once the dimensions, weight, and relative position of the optical parts of the instrument are determined, the design of the mounting, or mechanical portion, may proceed to a large extent independently. It is, therefore, the purpose of this paper to invite attention to the great variety of mechanical problems that arise in connection with the design of an astronomical telescope.

While the principal features of telescope mountings are familiar, we will mention the equatorial mounting, sometimes referred to as the German type. The equatorial head, or portion which surmounts the heavy pier or column, carries the polar axis at an angle exactly equal to the latitude of the locality. Actually, then, the polar axis is parallel to the axis of rotation of the earth. At the upper end of the polar axis, and at right angles to it, are bearings for carrying the declination axis. This axis in turn is rigidly fastened to the telescope tube at right angles to its optical axis. The combination of the two axes provides for universal movement of the telescope to virtually all points in the heavens. Accurate balance, so necessary to ease of operation and uniformity of motion of the telescope, is accomplished by carefully placed counterweights. Each axis is provided with graduated circles for easily reading the coordinates of stellar bodies as found in the tables giving star positions. The driving clock, which causes the tube to follow the apparent motion of the stars, is connected with the polar axis through a worm and worm wheel. Clamps make possible release of the worm wheel so that the tube may be directed to other heavenly bodies. Slow motions, either hand operated or mechanically operated, are provided for fine setting of the tube before employing the driving clock.

The equatorial mounting is by far the one most extensively used, most refracting telescopes and many reflecting telescopes having this type of mounting. Outstanding examples are the 36-inch Lick telescope and the 40-inch Yerkes telescope. In spite of the merits of this type of mounting, it has one outstanding disadvantage,—the interference which occurs in attempting to observe a celestial body on the meridian north of the zenith. The eye end of the telescope tube comes in contact with the column, making it necessary to reverse the tube on the polar axis in order to continue the observation. In visual observations this disadvantage is not serious, but it does present particular difficulty in photographic observations.

Another form of mounting, sometimes called the English type, is similar to that just discussed, except that the two polar axis bearings are placed on either side of the declination axis instead of both bearings below. This type requires two columns to support the polar axis, the north column usually being of considerable height. In order to provide clearance for the telescope tube, these columns must be placed far apart, which in turn requires a long polar axis. This type of mounting is well adapted to reflecting telescopes, the best example being the 72-inch Dominion Astrophysical telescope.

Another form known as the Fork type is of much later development. It resembles the German type in respect to bearings for the polar axis but is distinguished from it because the declination axis is replaced by trunnions which support the telescope tube at the upper end of the fork of the polar axis. This mounting is also well adapted to reflecting telescopes, the 60-inch reflector at Mount Wilson Observatory being the largest example so mounted.

A fourth form which somewhat resembles the English type is that employed on the 100-inch Hooker telescope at Mount Wilson Observatory. The polar axis in this mounting consists of a rectangular frame with a pivot bearing at each end. The telescope tube is mounted in this oblong frame on two declination trunnions. This mounting requires two columns or piers, the north column being higher for northern hemisphere observatories. While this mounting has been used for both refractors and reflectors, it has the outstanding disadvantage of two restricted areas, while the other types above described have restricted areas but in a single location.

The Coudé mounting is ingenious and should be here mentioned. It resembles a partially inverted "T" in which the telescope tube utilizes half the cross axis and nearly all of the polar axis. The object glass is located at the outer end of the cross axis. The celestial body being observed is twice reflected to the observer's postion at the upper end of the polar axis. The two telescopes in the Paris Observatory are the best examples of the Coudé mounting. There are several other types of mounting, many of which have been patented; but the applications of most of these are extremely limited and for that reason will not be mentioned here.

It is of interest to note that the era of large telescopes began about 1845 and since that time very rapid strides have been accomplished. During the first fifty years of this period the power of telescopes increased seven-fold. In that time the development of the largest refractors was accomplished. In more recent years the popularity of the reflector has greatly increased and the largest reflecting telescopes in the world have been developed.

Foundations. One of the problems which is seldom understood is that having to do with telescope foundations. It is of prime importance that a telescope be as free as possible from vibration and that its footings be so constructed as to eliminate settling. The larger the mounting, the greater is the problem of its foundation. For installations near the ground concrete or brick piers are successfully employed. It is always advisable to avoid high piers of small section for they are subject to oscillation and the transmission of vibration from passing vehicles or distant railway trains. Refracting telescopes having 10-inch or 12-inch objectives have been successfully mounted upon buildings by the use of properly arranged and keyed structural steel beams. These beams while supported on the main walls of the building must be free from the floors and entirely independent of the observing room.

In the case of large telescopes it is invariably necessary to employ massive foundations extending in some cases many feet into the ground. In the case of large reflectors of the English type, the piers often consist of hundreds of tons of reinforced concrete. Such piers resemble a massive "H" and extend from 45 to 50 feet above the ground. They must be carefully designed to insure stability and minimum vibration.

Bearings. Bearings used in mountings typify the progress of telescope engineering. In the earlier instruments only plain cylindrical bearings were used. While the speed of rotation is exceedingly low, it is nevertheless of prime importance to reduce to the minimum the element of frictional resistance in order that uniformity of motion may be accomplished for the telescope tube. The use of the telescope for astronomical photography will readily indicate the importance of this feature. As the size of the telescope increased, the increased friction was relieved by a system of rolls and compensating levers frequently applied to the upper end of the polar axis. Mercury floats were also employed for the same purpose, sometimes in connection with these rollers. But with the development of anti-friction bearings of the ball and roller types, the difficulties theretofore encountered were almost completely overcome. In all examples of present-day medium sized and large telescopes anti-friction bearings are employed. When properly installed and packed with lubricant, these bearings will function with complete satisfaction for years.

The 72-inch reflecting telescope of the Dominion Astrophysical Observatory offers an excellent example of the reduction of friction by the use of modern bearings. The forty-five tons of movable parts are moved by a spring scale pull of 3½ pounds in right ascension and of 2½

pounds in declination from the upper end of the telescope tube. The point of testing was twenty-six feet distant from the bearings.

Polar Axis. The polar axis is really the backbone of the instrument. It carries the entire weight of the moving parts and, being inclined to the horizontal, presents the problem of thrust load in addition to that of deflection due to radial load, the latter being complicated by a continual change in the plane of deflection as the axis rotates. In the fork type of instrument the fork is really a continuation of the polar axis structure introducing into the design of that member not only the more or less indeterminate stresses and deflections of the fork itself but also problems resulting from the concentration of almost the entire weight of the instrument on the bearing nearest the fork. Chief among these is the prevention of an excessive upward reaction at the other end of the axis. The divided-girder type of mounting escapes this disadvantage but calls for careful design to avoid objectionable variation in deflection at different positions of the axis. The English mounting, or cross axis type, has the advantage that the load is divided between two bearings and that the tube may be pointed in practically any direction. Whatever type is employed it is essential that the effects of torque and flexure in the mounting be virtually eliminated.

In the German mounting the upper bearing of the polar axis is placed so close to the declination sleeve and the bearings in the sleeve are located at points adjacent to their loadings so that this design permits the employment of elements of sufficient size to reduce flexure to a minimum. This principle is followed in British and American designs, while German telescopes use a lighter construction, together with a system of levers and counterweights to control deflection.

Tube Construction. There is no more important element of the telescope than its tube. The function of this member is to support and hold in constant alignment the optical elements of the instrument. This function is the same in the case of both refractors and reflectors. For the refracting telescope the tube is usually constructed of sheet steel with a cast iron section about mid-way in its length. It is to this cast section that the declination axis is bolted. The use of sheet steel permits the reduction in thickness of the sheets as they approach the ends of the tube. This practice assists materially in reducing the total weight of the tube. With this construction, the optical axis will maintain in the several positions of rotation, a position practically parallel to the mechanical axis of the tube centerpiece. By the application of auxiliary apparatus such as cameras, spectrographs, etc., no difficulty will be encountered, provided the design of the tube provides sufficient strength. The problem is one merely of adding sufficient counterweights to the opposite end to maintain correct balance of the tube at all times.

In the large reflectors, the problem is very different, for the excessive weight of the mirror and its cell places the center of gravity close to the lower end of the tube. Here the mirror cell is attached directly to the centerpiece which is either a great steel casting, or is built up of struc-

tural steel members. The remainder of the tube in the case of smaller reflecting telescopes is constructed of sheet metal, with diminishing thickness toward its upper end as already described. In the case of the larger telescope, some form of trussed or latticed construction is employed. In such tubes it is often possible to use to good advantage structural steel of commercial sizes; however, this does not permit the use of longitudinal members having a gradually decreasing section. Such members would be ideal if obtainable without prohibitive cost. This circumstance suggests the benefits to be derived from welding and the use of alloys lighter than steel. The conditions surrounding the telescope tube are in some respects similar to those encountered in aircraft design. It is within reason, therefore, to look forward to future designs which will employ modern welding similar to that now well established in the aircraft industry.

An important consideration in the design of the tube is the method of attaching secondary mirrors and other apparatus to the upper end, as it is necessary to arrange for three or more optical combinations. At least three methods are successfully employed. The large telescopes at Mount Wilson Observatory, as well as instruments in British and German observatories, have removable cages for these mirrors. These cages can be removed and replaced without getting the combinations out of adjustment. The weight of these cages requires the use of a crane for handling. A second method is that employed by the 72-inch Dominion Astrophysical telescope; here a centerpiece is attached to the tube structure at its upper end by four thin diaphragm plates. The secondary mirrors in their cells are then bolted to the bottom of the centerpiece. This system has the great advantage of reducing the weight factor of the removable elements; accordingly only a small hoist is required in lifting the parts. A third method employs a centerpiece mounting in the upper end of the tube which is in general similar to that of the second method, the difference is in the size of the cylindrical hole in the centerpiece which permits the passing of the mirrors in their cells through the centerpiece and then bolting them in place. This method permits of a shorter over-all length of tube but the larger centerpiece obstructs a somewhat greater percentage of light from the main mirror.

Since the secondary mirrors are mounted directly in front of the main mirror, it is desirable to provide for supporting the secondaries so as to intercept the least possible light; at the same time the centerpiece support construction should permit the passage of the cone of light to the prime focus whenever that position is to be used. Accordingly, the method which obstructs the minimum amount of light in all cases is that preferred.

In recent large reflecting telescopes, provision has been made for a protecting cover for the main mirror as an insurance against damage and changes in temperature. A successful type of cover is the triangular leaved shutter, hinged to fold inwards a few inches above the mirror surface.

Mirror Cell and Supports. Few scientists, other than those directly associated with the operation of telescopes, realize the importance of that element of a large reflector which holds in position the great mirror. Were the mirror to remain in a fixed position with reference to the zenith, there would be but one condition with which to contend, *i.e.* properly supporting its weight. But in actual use, the telescope tube traverses all parts of the heavens and in so doing, the mirror in its cell at the lower end of the tube takes every angle between the horizontal and the perpendicular. Accordingly, it is essential that the mirror be at all times supported so that, whatever position the telescope tube may take, the mirror will still be in correct optical relation with the center line of the tube.

The mirror cell usually takes the form of a pan, deep enough to permit free circulation of air round the mirror to equalize the temperature, and sufficiently rigid to afford proper support for the mirror regardless of the direction in which the tube is pointed. In addition, the cell may be required to provide a place for attaching a spectrograph or similar device, often of considerable weight, and yet must be readily removable to permit access to the mirror for re-silvering.

A system of pads or pans has been successfully employed for the bottom support of the mirror. The number and size of these pads depends upon the size of the mirror and the area of the sector to be supported. For correct collimation it has been found that the principle of three point support is imperative; the number of the supports being in all cases divisible by three. A common method used, both in this country and abroad, consists of beam arms carried by three collimating screws which in turn support single, double, or triple groupings of pads. The connection at each point is a spherical bearing, located at the center of gravity of the member being carried. This system insures an automatic and even distribution of the weight, and if properly designed, the amount of flexure in all elements is uniform. It is interesting to note that at the meeting of this Association at Albany, in 1851, Josiah Lyman exhibited a 9½-inch speculum with an ingenious system of supporting layers.

In the case of very large and heavy mirrors, it is essential to provide a system of supports in which the individual pans are counterpoised and supporting fulcrums are attached directly to the framework of the mirror cell. In this system also each element must have the support at the center of gravity of its sector. This arrangement releases the collimating screws so that they carry only their proportion of the load. A mirror must also be adequately supported on its edge in order to reduce to the minimum its tendency to sag when in a nearly horizontal position. A successful method for accomplishing this includes two solid and two spring sectors equally spaced, the latter also constructed so as to avoid gripping and at the same time prevent movement of the mirror. In some of the German telescopes zinc blocks are inserted between the mirror and its cell to compensate for difference in expansion. In the case

of the two largest American mirrors there are cork lined rings surrounding their edges and these are counterpoised at twelve equally spaced positions. The cork lined ring is held in fixed position by two solid and two spring sectors, using knife edge contact located in the plane of the center of mass of the mirror.

Driving Clock. There is no more accurate element of a telescope than its driving clock—that mechanism which causes the tube to move as the stars progress across the heavens. The perfect balance of the tube serves to greatly lessen the task of the driving clock by making its load uniform regardless of the angle at which the tube may be pointed.

It was in 1825 that Joseph Fraunhofer, the eminent physicist of Munich, invented the driving clock. This was a great advance in telescope history, for it made possible accurate observations covering long intervals. Although slow of adoption at first, subsequent developments in the design of driving clocks led to the accurate mechanisms known to us today and used on all astronomical telescopes from small amateur instruments to those in our largest observatories.

The driving clock used in nearly all the observatories in this country is constructed with a double conical pendulum mounted isochronously, that is, the speed of revolution is independent of the position of the balls within certain limits. This permits the adjustment of the pendulum so as to compensate for a considerable variation of driving torque, with only a momentary, and hence imperceptible, deviation from a given speed. The driving power is furnished by a weight system connected to the gear train so that hand or motor winding does not affect the torque.

Since atmospheric refraction causes an apparent variation in the motion of the stars, it is necessary to provide means for retarding and for accelerating the slow motions in right ascension. These are frequently referred to as setting motions (for centering the image) and following motions (for maintaining the image as required). This has been successfully accomplished by a double planetary differential mechanism so located in the driving gear train that when placed in operation it adds to or subtracts from the normal speed of the driving worm.

The drive from the clock to the polar axis of the instrument is by means of an accurate worm and worm wheel. The worm wheel is mounted with anti-friction thrust and radial bearings on the axis, and is clutched to it as required by the operator. A worm wheel of nine feet in diameter and two tons weight can be kept in motion by a pull of one-half pound at its rim. In some cases the differential train has been omitted and replaced by a motor and a system of gearing between the clock and the driving shaft. This system is used to obtain various speeds for following.

Clocks of this construction have been used on the largest telescopes in the world and in some cases for more than forty years with entire satisfaction. There is an English clock having a motor driven weight system with centrifugal governor, controlled by rubbing pieces on an ad-

justable contact ring. Its drive then passes through two double sets of planetary differential gearing, one set used to correct the governor speed by means of an automatic control from an observatory pendulum, while the other is used for manual following.

Probably the German clock having the most extensive application is one in which springs oppose the centrifugal action of the pendulums, while the resisting friction is obtained from a contact ring. The driving force is obtained through a motor driven weight control system. The speed of the governor is rectified through a differential controlled by an observatory pendulum.

Slow motion is the term applied in telescope engineering to indicate the slow speed of advance of the telescope tube in setting. There are slow motions in both coördinates. It usually means the speed which brings the star to the center of the field of view immediately after clamping the driving mechanism. In small telescopes all such motions, both fast and slow, are accomplished by hand, but in the larger mountings, motorized controls are necessary.

The declination slow motion is obtained from an electric motor attached to a system of reduction gearing, magnetic or solenoid operated clutches being used to select the desired combination and to control the direction of rotation. Thus, the means are provided for rotating a worm at the desired speed for moving a worm wheel or sector which is keyed or clamped to the declination axis. The slow following motion of the clock is from ⅜ to ½ minute of arc to a minute of time, and the setting motion is from 7½ to 12 minutes of arc to a minute of time.

Quick motions, in both right ascension and in declination are essential for speed of the telescope from one celestial object to another. Quick motion is, of course, employed in advance of the slow motion just described. Quick motions are obtained through spur, spiral, or worm gearing, depending upon the design, a large spur gear keyed to the axis and driven through a pinion clutched to a system of motor driven reduction gearing being the usual arrangement. An interlocking system of clutches is necessary in this case so as to keep the instrument in control at all times and it is desirable to have one set of these clutches spring operated so that, should the electrical power fail or be thrown off at any time, the mounting will be locked in position and accidents avoided.

The rate of motion for quick setting varies with the size of the instrument. A 36-inch reflector could probably be turned a complete rotation in three minutes while our large mountings can be moved about 45 degrees per minute of time. In the case of one large reflector, the average time required from the end of the exposure on the spectrum of one star to the beginning of that on the next is only about four minutes.

Electric Control. Smaller mountings use electricity only as a means of illuminating the circles and the micrometer cross wires and in connecting and operating some accessories such as the chronograph. The application in the larger instruments is quite extensive and must also

include the control of the dome and its various elements. For larger installations, master switches must be located at some convenient place from which the right ascension and hour circles can be easily observed. These switches control the setting of the telescope in quick motion, the release and proper clamping by the necessary clutches, also the rotation of the dome and opening of its shutters.

Solenoids, or magnetic coils, are used extensively in the mountings as a means of operating elements where remote control is necessary. Examples of these are the actuating of the slow and setting motions of the clock, various clutches and their interlocking systems of safety devices. Motors ranging in size from 1/20 to 10 horse power have various applications, mention having been made of those operating the clock, such as operating minor protecting shutters, focusing secondary mirrors, quick and slow controls. The dome also requires motors for turning, opening and closing the large shutters, operating the upper and lower wind curtains, and, in the case of large reflectors, the observing platforms. In some cases, motors are also required for elevating floors, observing chairs, various cranes and hoisting apparatus.

The observer's control of the telescope is usually obtained through various push button switches contained in some form of light portable box, which can be either hooked onto the instrument or the observer's belt; this is connected by means of flexible cables directly to the operating elements or the switchboard. The main switch board for a large mounting carries various forms of special apparatus aside from those of standard construction, requiring possibly 50 square feet of panel surface, the installation using upwards of three miles of wire.

Accessories. Many other features could be discussed if time would permit; such as 3-prism spectrographs and their collimating devices and cameras, protecting and diaphragm shutters for the large mirrors; also many other devices and the methods of handling them; the apparatus required for silvering the large mirrors; the elevating floors required for large refractors and the development of observing bridges for large reflectors, domes, shutters, and wind curtains. All these enter into the problem of a large observatory, aside from the design of the actual building.

Conclusions. Speculating as to the future of the telescope, it seems evident that the difficulty in obtaining larger refractor lenses indicates that the developments in the near future may be along the line of reflectors. The future development of the reflector will depend largely upon optical science for the mechanical problems of larger mountings are, for the most part, all susceptible of solution. Even though advance in the development of our instruments has placed America in a corresponding position in the field of scientific accomplishment, our hopes and ambitions can well be directed toward larger instruments in that we may learn more of the limitless universe of which our earth forms a miniature part.

PLANET P. COMET 1930 III, WILK, NUMBER 590

By WILLIAM H. PICKERING.

The orbit of this comet is an unusually interesting one, because it belongs to the group Class *C* Type *P*, the majority of which are associated with planet **P**, the next planet, (or perhaps the next but one), beyond Pluto. In 1909 there were 20 comets in this group, and of this number 15 were associated with the planet. The kind of association is the same as that which binds the comets of Class *A* Type *N* to Jupiter, and of Class *B* Type *O* to the planets Saturn, Uranus, Neptune, and Pluto. In 1925, 22 comets out of a total of 41 were still associated with Jupiter, the remainder having disappeared for over 25 years. The Class *B* group contained a total of 19, of which one, Peter's, disappeared more than 80 years ago. The association of comets with their controlling planet involves two quantities, first the Class,—the location of the aphelion on the celestial sphere should lie near to the plane of the orbit of the planet, and second the Type,—the aphelion distance should be analogous to that of the planet. In other words the comet's aphelion must lie near the planet's orbit in all three dimensions. The interesting peculiarity of the Class *C* group is that while the aphelia of the two other classes are closely associated with the plane of the ecliptic, the aphelia of this group are associated with a great circle whose node is in longitude 351° and its inclination is 37°. The zone in which the aphelia lie extends 20° on either side of its median plane, and covers one-third of the celestial sphere. Sixteen out of a total of twenty-one aphelia now lie within this zone, one lies 9° outside of it, and four are remote (see Figure 1 taken from POPULAR ASTRONOMY, 1928, **36**, 421). The aphelion distance of this recent comet is near the mean value of the group, and the probability that 16 points out of 21, within any given range of distances should by accident lie within one-third of the area of the celestial sphere, and that this area should lie along a great circle, is one chance against many hundreds. It is therefore practically *certain* that this distribution is due to some definite cause. It is as certain as it was that the perturbation of Nepune, by means of which we predicted and located Pluto within 1° of its true longitude, rendered the existence of that planet certain. (POPULAR ASTRONOMY, 1931, **39**, 2.)

Up to 1905, comets belonging to this group were coming at an average rate of one in every six years, and since some of the earlier comets in the last century, especially the southern ones, were poorly observed, it was concluded that they really came on the average once in every five years. Since that date, however, no comets of Type *P* arrived for twenty-five years. If they came, they were not favorably situated for observation or, what is quite as likely, their perihelion distances carried them no nearer the Sun than the orbit of Mars or Jupiter, and for this

reason they were not seen. That another comet of this group should have at length appeared is for this reason a matter of interest. Its elements, computed by Banachiewicz, are given by Crommelin in his sum-

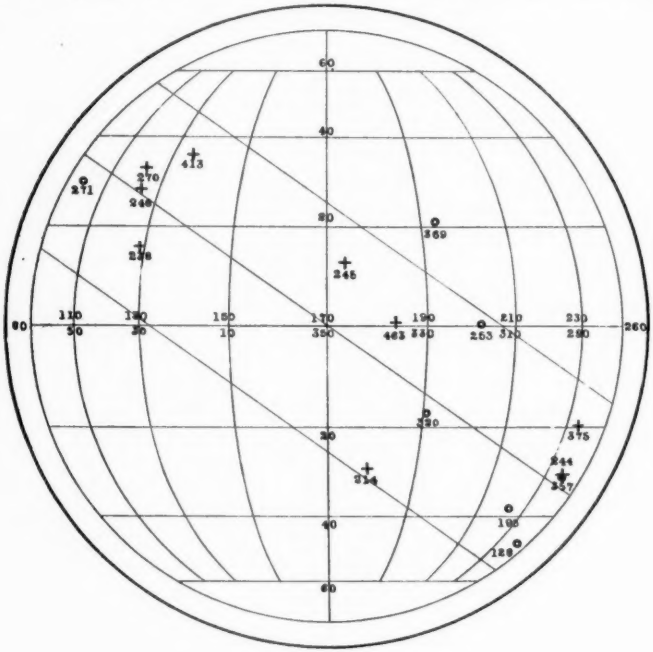


FIGURE 1.
APHELIA OF THE COMETS OF CLASS *C* TYPE *P*.

mary of cometary orbits in the *M.N.*, 1931, **91**, 378. Instead of the eccentricities he gives the periods, from which and the perihelion distances the eccentricities can be deduced. It is an excellent idea, but it is regrettable that he has not room to give both periods and eccentricities. For comet 1930 III the eccentricity is 0.99198, and the aphelion distance 120.2. This brings it not far from the middle of the group in aphelion distance. The latitude and longitude of its aphelion are —42°.30 and 292°.43. Its position in Figure 1 therefore lies between that of comet 128 and 195, but since it is on the farther side of the sphere, while they are on the nearer, its position should be marked by a cross, and its longitude will differ from their mean by 60°.

When the first orbit of Pluto was published by the Lowell Observatory, and it was seen to be that of a comet, it was shown that although its aphelion distance, 180 units, brought it well within type *P*, yet the latitude and longitude of its aphelion failed to conform to Class *C*. (The

Trans-Neptunian Comet, POPULAR ASTRONOMY, 1930, **38**, 341.) When soon after the hyperbolic orbit was published by the Yerkes Observatory, it was evident that neither in Class nor Type did it conform to this group of comets. Later when the true planetary orbit was announced by Crommelin, and then confirmed at the Lick and Mount Wilson Observatories, it was seen that the errors of the two earlier orbits were caused by an erroneous measure, amounting to 3", of one of the earlier January photographs, and was not the fault of the computers.

PRIVATE OBSERVATORY, MANDEVILLE, JAMAICA, B. W. I., APRIL 27, 1931.

COMMEMORATION OF THE TERCENTENARY OF THE DEATH OF JOHANN KEPLER (1571-1630)

By FREDERICK E. BRASCH.

The History of Science Society on Wednesday, December 31, 1930, in joint session with Sections A, D, and L, of the American Association for the Advancement of Science commemorated the tercentenary of the death of Johann Kepler, the great German astronomer and mathematician, who died at Ratisbon on the 15th of November (N.S.) 1630, in the fifty-ninth year of his age.

The commemoration of the birth or death of great masters in any field of science offers a rare and appropriate opportunity to review their contributions to science and civilization in the light of our present progress and development. It also contributes to the great factor leading to the humanizing of science, and establishes a vital cultural relation between the past and the present. The History of Science Society is particularly anxious to contribute to this form of observance of great historical and scientific events, and to pay due homage to the minds of those who have laid the foundations of modern science. In fact, it is the duty of the present to observe with historical introspection the work of the past.

The Kepler commemoration by the History of Science Society consisted of three papers by well-known scholars in their respective fields of research. The Presiding Officer, Dr. Harry W. Tyler, Consultant in Science at the Library of Congress, in a fitting manner opened the session with introductory remarks by quoting a part of the speech of Sir Arthur S. Eddington of Cambridge University, given at the birthplace of Johann Kepler in Weil-der-Stadt, on July 20, 1928. (See *Die Naturwissenschaften* 14 November 1930, page 941.)

The first paper was given by Dr. Dirk J. Struik, of the Massachusetts Institute of Technology, on Kepler as a Mathematician. In the absence of Dr. Struik this paper was read by Dr. L. C. Karpinski, of the University of Michigan, which in part was as follows:

The history of mathematics may be studied from the point of view of

different periods, or it may be studied as the history of individuals. In both cases, however, we must look for the general ideas and tendencies of the age, and show how they are related to the economic, the political, the religious structure. Discoveries are never made independently of the organization of society, its ideas, its conflicts, its resources. The work of a genius does not make exception, on the contrary, it is repre-

Courtesy of the Journal of the Royal Astronomical Society of Canada.

KEPLER'S MONUMENT IN WEILDERSTADT.

In the left picture is the monument as decorated for the visit of the Astronomische Gesellschaft in 1928. In the right picture is seen Professor Eddington addressing the gathering. Just at his left, bareheaded, is Professor Strömgren. At the far side with hat in left hand and umbrella in right is the Mayor of Weilderstadt. (*Photo by C. A. Chmt*, 1928.)

sentative of all these tendencies. The history of a genius, be it Alexander or Archimedes or Michael Angelo, reflects truly the history of the age.

Mathematics has only this special quality, that it is often more difficult to trace, in the subtle speculations of the thinker, the life of his time. It is not easy to connect Eudoxus' theory of proportion with the Athens of the Golden Age, or Gauss' theory of biquadratic residues with

the age of Napoleon. But there is no accident in the development of real science, be it abstract mathematics or philosophy. To make these relations clear is the true aim of history of science.

In the case of Kepler there is not much to doubt. The character of his discoveries, not only in astronomy, but also in mathematics, is typical of the period around 1600. They are as intimately connected

Courtesy of the Journal of the Royal Astronomical Society of Canada.

KEPLER'S BIRTHPLACE.

The house under the arrow is that in which Kepler was born. It is just off the market place in the midst of which is the monument to Kepler. In the house is now a confectionery shop of which Theodor Koppler is proprietor. (*Photo by C. A. Chant,* 1928.)

with the economic and political history of Central Europe as the history of his life. It is well known how completely his theory of the solar system fits into the general frame of his time, when the struggle for cosmological conceptions was one of the main issues in the controversies of the nations. It is also well known how the accurate observations of

Tycho Brahe, the base of Kepler's theory, were due to the perfection of the observations, possible only in an age of inventions. Kepler's age was technically as far above antiquity as his theory stands above that of Ptolemy.

It is not different with Kepler the mathematician. It would be closing our eyes to the very essence of his genius, if we would relate his discoveries as so many different disconnected items. In few mathematicians is the source and the tendency of their efforts so clear. They are always, directly or indirectly, those of the interpreter of the cosmos. The key to his mathematical work lies there where the key to his astronomy lies, in his constant struggle for a picture of the universe. Whether he be busy arranging regular polygons to a pattern, or measuring the volume of wine barrels, or estimating the value of an elliptic integral or overwhelming the reader with the extent of his computations, it is always Kepler studying the laws of the universe. He is possessed with the same spirit as the Ionian philosophers before him, or as Poincaré or Einstein after him, with the desire to know how the universe is built. He attacks his problem with the mental makeup of a man of his time, where Neoplatonic and Neopythagorean concepts of antiquity struggle with Lutheran and Catholic concepts of the present.

From this point of view Kepler's first and Kepler's last mathematical book are the most characteristic. Both the "Mysterium cosmographicum" which he published when he was 25 years old, and his "Harmonices mundi," which appeared when he was 48, deal with the search for the harmonies in the universe. This is, and probably will always be as long as man believes in the possibility of the interpretation of nature, in the search for certain symmetries. Regular solids, regular polygons, combinations of those in patterns, figurative numbers, musical harmonies and other simple numerical relations are Kepler's material, which he combines with a keenness in which is as much charm as piety and devotion. But also his regular explanation of the solar system, the "Astronomia nova" of 1604, written in the period between the two previous books, contains a fullness of mathematical results. There it is not so much the mystical side of the mathematical notions, as the extremely practical necessities of computation that furnishes the material. It is true, Kepler's consistent preference for circles as the most perfect figures dominates the book until the last chapters compel him to introduce ellipses, but the valuable contributions to mathematics lie elsewhere. They are in the frequent introduction of infinitesimals, of infinite sums, of what we now call integrals. As such, the work is of tremendous importance for the invention of the calculus. No one since Archimedes had ever used infinitesimals so freely and with such surprising efficiency. Mathematicians might attack the lack of rigor, as they did in the case of the book on wine barrels, and we may even grant that the attack was justified, but the results were there, and criticism could only attack their surface, not their heart. But the New Astronomy leads also in other aspects to new methods in mathematics. There we find

Kepler's equation, one of the first transcendental equations, connecting x and $\sin x$, and here we find an approximation for the perimeter of the ellipse. And finally, the whole book is a vindication of Apollonius' theory of conic sections, which through Kepler's endeavor turns from an abstract piece of mathematics into one of the first tools of the applied scientist.

It is no miracle that such a student of Archimedes would try to develop the methods of his master. Through this desire the "Stereometria Doliorum" was born. Kepler found that wine dealers used primitive methods to find the volume of the barrels. The exact computation of their volumes attracted him as a field where he could apply Archimedes' theorems on spheroids and conoids. And so he developed a new theory of ellipsoids and other figures of revolution, which is another important step toward the invention of the calculus. He did not stop at the computation of the volumes alone, but ventured into maximum-minimum problems. He found that the variation of a function varies very little in the neighborhood of an extreme value, a remark influencing Fermat's later work on the subject. Leibnitz, in his first paper on differential calculus, took as his starting point just such questions. And so we see that wherever Kepler worked he opened new roads, blazing the trail not only for modern astronomy, but also for differential and integral calculus. His investigations on regular figures find their place today in modern group theory, his work on logarithms put computation on a more modern basis. He influenced Fermat, Cavalieri, Newton, and others. His results were not only important, they are of imposing grandeur, because of their unity and their connection with the solution of one of the most tremendous problems that science has even attacked.

The following is a summary of the second paper, Kepler as an Astronomer, given by Dr. W. Carl Rufus of the Detroit Observatory, University of Michigan. This paper brought out many interesting facts concerning the second phase of Kepler's life, namely, his astronomical career.

The combined labors of five astronomers solved the problem of the motions of the heavenly bodies. Copernicus, a Pole, advocated the heliocentric doctrine; Tycho Brahe, a Dane, provided more accurate observations; Kepler, a German, formulated the three laws of planetary motion; Galileo, an Italian, laid the foundation in dynamics; and Newton, an Englishman, completed the solution by his generalization, the law of gravitation, based chiefly on Kepler's work.

Premature birth, frequent illness, shiftless father and illiterate mother, constituted early handicaps; but Kepler at twenty obtained a master's degree in theology at Tübingen. He meditated on "the nature of heaven, of souls, of the elements, of the essence of fire," etc. Under Maestlin he studied the Copernican system, whose simplicity and harmony appealed to his mystical nature.

In 1594 he undertook lecturing in mathematics and astronomy at Gratz to diminishing numbers. His "Mystery of the Universe," 1596,

defended the Copernican doctrine and presented mystical reasons for the number and distances of the planets based on the five regular solids. He needed better data to test his theories and after a few troubled years joined Tycho at Prague where he obtained possession of observations made at Uraniborg. His "Commentary on Mars," 1609, and "Harmony of the World," 1619, contain his epoch-making laws discovered among the harmonies hidden in Tycho's data,—the radius vector of a planet sweeps over equal areas in equal times, the orbit of a planet is an ellipse with the sun at a focus, and (in the later work) the squares of the periods of revolution of any two planets are proportional to the cubes of their mean distances from the sun. The third law occasioned great exultation: "The book is written; to be read either now or by posterity, I care not which; it may well wait a century for a reader, as God has waited six thousand years for an observer." Kepler's work on Mars ranks among astronomical masterpieces like Ptolemy's "Syntaxis," Copernicus' "Revolutionibus," and Newton's "Principia." The other works are general; Kepler's illustrates a modern tendency toward limited and specific investigations.

His "Supplement to Vitello," 1604, gave the first reasonable theory of refraction, applied in his "Dioptrics," 1611, to lenses and telescopes including proposed positive eyepieces. The "Epitome of Copernican Astronomy," in parts 1618, 1620, 1621, helped to establish physical astronomy. The distance of the sun increased three fold was yet one-seventh its true value. Eclipses were explained, the corona interpreted as a solar appendage, and stellar distances improved. Kepler's last great work as Imperial Mathematician was the "Rudolphine Tables," 1627, which remained the standard for a century.

Kepler's practice of astrology, mystical speculations, and weakness as an observer, are compensated by his creative imagination, indefatigable labors, adherence to empirical tests, and devotion to his work as divinely appointed. He was preeminently a devout astronomer, "thinking God's thoughts." In his life and contributions science and religion were united.

Kepler was a typical man of his period in that he possessed unusual knowledge in more than one field of learning. He was steeped in mysticism, and this phase of his life was carefully considered by Dr. E. H. Johnson, Professor of Physics, Kenyon College, who spoke as follows:

It is not generally known that Johann Kepler, who died just three hundred years ago, was a mystic as well as an astronomer and mathematician. Among his contemporaries at the beginning of the 17th century were men famous at the time as astrologers and alchemists, and others whose fame has grown in later years because of their pioneer work in the physical sciences. Kepler seems to have been a mixture of the two types. He was convinced that astrology had a very real basis of truth, although he scorned the common run of astrologers and regarded their predictions as mere nonsense.

Since the days of Plato philosophers had employed mystical numbers

and strange formulae to explain natural phenomena. What appears to us a foolish superstition was often the accepted science of the time. Long usage had made original thinking almost impossible. This was especially true in astronomy which had had much of its early development as an adjunct to the art of forecasting events in the lives of human beings. Not until Kepler's time had there been amassed an amount of observational data sufficient to point out the true course for progress. Many of the books then available were full of magic and necromancy. Hence, it is not surprising to find that Kepler struggled for years with all sorts of mystical schemes before he arrived at those laws of the solar system on which his fame as an astronomer rests. At the same time he found the astrological doctrine of "aspects" and "influences" acceptable, partly because the casting of horoscopes afforded him a means of livelihood, and partly because he found so many things in heaven and earth that he could not explain otherwise. For example, comets apparently did not follow the orderly courses of the planets, and several striking coincidences had strengthened the ancient belief that they were sent as omens of evil to mankind. He could not escape the general idea that, after all, the aspects of the heavenly bodies do influence human affairs. Similarly, he accepted the old Pythagorean theory of the music of the spheres, and he actually wrote short scores showing the tones which he believed were produced by the planets.

Perhaps the strangest of all of his notions concerned the nature of the earth itself. The action of the tides suggested the pulsating, breathing motion of a living being, and Kepler declared that he was prepared to consider the earth as an animal if further discoveries should disclose parts functioning like bodily organs.

In short, Kepler was at once a great astronomer and a confirmed mystic. His real accomplishments are the works of a mental giant, while many of his speculations seem worse than childish to us. But it was this fertility that led him to his most glorious discoveries, and yet he was not lacking in sufficient courage to throw away cherished theories when he became convinced of their errors. When we consider the times and circumstances in which he lived, it is clear that a complete emancipation was too much to be expected. His association of mystical ideas with physical facts and his seeking of relationships between extramundane and human affairs, were sincere attempts to find the principle of unity in the universe.

On the day preceding the Kepler program it is interesting to note that two papers were presented at the Session of the History of Chinese Science and Culture which were of unusual interest and importance to the history of science, Dr. Arthur W. Hummel of the Library of Congress giving a broad survey of the literature of Chinese Science, and Dr. David Eugene Smith, of Columbia University, presenting a paper on the history of Chinese mathematics.

In the afternoon of the Kepler session, at which Dr. William H. Welch, the recently elected President of The History of Science Society,

presided, the following addresses were given:

1. Retiring Address of Vice-President of Section D. Harlow Shapley, Harvard College Observatory, Cambridge, Massachusetts.

2. Historical Instruments in the Adler Planetarium and Astronomical Museum, Chicago, Illinois. Philip Fox, Chicago, Illinois.

3. A Character Sketch of Sir Isaac Newton. Louis T. More, University of Cincinnati, Cincinnati, Ohio.

4. Plans and Outlook for Section L. Joseph Mayer, Library of Congress, Washington, D. C.

LIBRARY OF CONGRESS, WASHINGTON, D. C.

FIREBALL OF OCTOBER 7, 1928

By O. E. MONNIG and C. P. OLIVIER.

A very brilliant fireball appeared over the southeastern part of the state of Texas about 9:40 P.M., C.S.T., on October 7, 1928, and after travelling south fell into or ended at a very low altitude over the Gulf of Mexico, at a point equidistant from Corpus Christi and Brownsville, and about 100 miles from each of them. Efforts were at once made by O. E. Monnig of Ft. Worth to secure observations from eye witnesses. In this he was greatly assisted by the newspapers, some of which published not only the mere request for observations, but the whole A.M.S. questionnaire. Thanks to these, and numerous personal letters, he was finally able to get reports from 14 persons at 8 stations, scattered in a general north and south direction from Hamilton to Brownsville. A list of the observers follows:

Station No.		
1	Miss Werna Lenert, Louis Beazley	2 miles south of Brenham
2	James A. Emmett	Hamilton, Texas
3	I. C. Kerridge	Corpus Christi
	H. S. Guy	Corpus Christi
	Miss Alyce King	Corpus Christi
	A. P. Herndon	Corpus Christi
	F. D. Warren	Corpus Christi
4	Francis Blossman	Clarkwood, Nueces County
5	Mrs. Vera True	Bishop, Nueces County
6	Mr. and Mrs. R. J. Ball	Kingsville
7	Capt. Herbert V. Scanlan	4 miles north of Brownsville
8	George A. Toolan	6 miles south of San Benito, Cameron Co.

As always happens, some days or weeks elapsed before the reports were made. Persons have time meanwhile to forget what they saw, and most are unused to exact estimates of either time, distances, or angles. Therefore from the data at hand, the writers always have to choose what seems most exact. The beginning point of the derived path in this case depends on the observations from No. 1, which we interpret as showing that the fireball passed west of the zenith at an alti-

tude of 75° as seen from that station, and on those from No. 2, which state that it started about S.E. of there at an altitude of 40°±. As the fireball had been seen farther north from No. 1, before passing the point adopted, it is obvious that the actual beginning point was not derived by the writers. The point given is, however, the first on the path which we believe can be determined with any degree of accuracy, and the true beginning point was probably not over 20 miles farther north.

For the end point, J. A. Emmett later measured the marked point of disappearance at $a = 338°.6$, $h = 0° 20'$. This line is the fundamental one on which we must place our derived end point. It is considered the most exact observation of all, as it was made with a theodolite. We then use I. C. Kerridge's azimuth, derived from the fact that from his home the object burst over (interpreted to mean, in view of all other accounts, that it disappeared behind) the Nixon Building. This gives an azimuth of 314°. Almost concurrent with the intersection of these two azimuth lines is the line derived from Scanlan's "it . . . apparently intended to strike at about Point Isabel." The three best azimuths thus almost coincide, and it is believed that the end point is more accurately determined than can ordinarily be hoped for from such a limited number of reports. It is true that we thus partly ignore other azimuth estimates, but the probable error of these is large, and the circumstances under which they were made are of such a nature that this course seems necessary. In any case the average of 4 of the others agrees with the chosen point quite well.

Every observer except Kerridge and Herndon reported the fireball to have gone practically to or below the horizon. As both the persons mentioned were in Corpus Christi, with buildings all around them, we assume that from all south Texas stations the fireball appeared to reach the horizon. To be specific, we assume that it ended on the horizon of Corpus Christi, the fragments probably falling into the Gulf. The final numerical results are:

Fireball began over*	$\phi = 30° 08'$ $\lambda = 96° 46'$
Fireball ended over	$\phi = 26° 50'$ $\lambda = 96° 09'$
Projected length of path*	232 miles
Altitude of appearance*	100 miles
Altitude of disappearance	1 mile
True length of path*	252 miles
Slope	23°.1

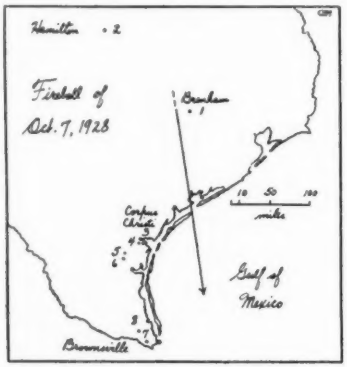
Several considerations support the path adopted. It goes 13°.5 west of the zenith at Brenham—within 1°.5 of the point which the observers there gave. It explains why people in Corpus Christi and vicinity reported the light as "blinding," while from near Brownsville it is reported as a "pale light": the fireball passed right by Corpus Christi, but never got as far south as Brownsville. Greater publicity at the latter place elicited fewer reports.

The observations include estimates of slope from the several southern

*See statements above.

stations, and would be better satisfied in general by assuming that the fireball moved more nearly horizontally for the first half of its visible path, and then followed a course making a 45° angle with the horizon. However, due to the uncertainty of the data, it is necessary to treat the path as in one straight line.

The mean of the estimates of those seven who thought they saw the whole path is 3.3 seconds, giving an average velocity in our atmosphere of 76± miles a second. It is certain that this is too high. Some of the estimates perhaps referred to the duration of the train.



The best datum of all is the azimuth of its plane of motion, which was towards 353°. This can scarcely be more than 5° in error. The altitudes of the beginning and end points are also probably correct to within 20 miles and 3 miles respectively. The position of the end point in latitude and longitude is quite certain, of the beginning point, uncertain; on these obviously depends the length of path. Using the figures given above, the radiant was about $\alpha = 216°$, $\delta = +82°.6$. The data are not sufficiently accurate to make the computation of an orbit desirable.

In color, the fireball left the impression of both red and blue. At No. 7 the nucleus was described as blue, the surrounding and following flame as very red—probably the most accurate description. No. 8 reported "bluish-fire," Herndon, at No. 3, "meteor blue-white, trail somewhat more red." At No. 2, general reports of "green, red" were obtained. The flash that illuminated the country was white or bluish. A yellow-red train was left, but this lasted only a couple of seconds.

From several points the brilliancy clearly exceeded that of the Moon, and was even compared to that of the Sun, two reports being that it was blinding. Several observations indicate an apparent diameter of ½°, but instead of being circular, the head seems to have carried a short, broad tail. The size and brilliancy were both very remarkable. Apparently it burst, or at least flared up immensely near the end of its course. There is one report of the mooted "swishing" sound, which the observer

mentions first in narrating the circumstances of the fireball.

The initiative and labor of collecting all the reports, the digesting and preliminary writing up of the same, and the selecting of the salient points in the descriptions were all due to O. E. Monnig. The revision of the data and final computations were due to C. P. Olivier.

The authors desire to express their grateful acknowledgment not only to the individuals who contributed reports, but equally to the Texas newspapers who so kindly published articles on the subject and requests for information. Only by their coöperation was any success possible.

PLANET NOTES FOR JULY AND AUGUST, 1931

By CLIFFORD E. SMITH.

The *Sun* will be moving southeast from the central part of Gemini, across Cancer, to the central part of Leo. On July 5 at 4:00 P.M., C.S.T., the earth will be at its aphelion point, that is, the earth will be at the point in its path around the sun which is farthest from the sun. The distance of the earth from the sun, at aphelion, to the nearest 100,000 miles will be 94.5 million miles. The position of the sun on July 1, August 1, and August 31 will be, respectively: R.A. $6^h\,36^m$, Decl. $+23°\,12'$; R.A. $8^h\,41^m$, Decl. $+18°\,20'$; R.A. $10^h\,33^m$, Decl. $+9°\,5'$.

The phenomena of the *Moon* will occur as follows:

Last Quarter	July	7 at	6 P.M.	C.S.T.
New Moon		15 "	6 A.M.	"
First Quarter		21 "	11 P.M.	"
Full Moon		29 "	7 A.M.	"
Last Quarter	Aug.	6 "	10 A.M.	"
New Moon		13 "	2 P.M.	"
First Quarter		20 "	6 A.M.	"
Full Moon		27 "	9 P.M.	"
Apogee	July	6 "	8 A.M.	"
Apogee	Aug.	3 "	2 A.M.	"
Apogee		30 "	3 P.M.	"
Perigee	July	18 "	6 A.M.	"
Perigee	Aug.	15 "	4 A.M.	"

Mercury will be preceding the sun in its apparent motion among the stars, but at the beginning and end of this period it will be within eight degrees of the apparent position of the sun. On August 8, Mercury will be at greatest elongation east, and at that time it will set about two hours after the sun, therefore it would be a very favorable time to look for Mercury at sunset. The distance of the earth from Mercury will decrease from about 123 million miles to about 60 million miles. Conjunction with the moon will occur on July 16 and on August 15, and conjunction with Neptune will occur on August 1. During the period of favorable observation Mercury will appear somewhat brighter than the first magnitude.

Venus will not be in a position favorable for observation during this period, since conjunction with the sun will occur on September 8. At the beginning of July it will rise about an hour before the sun, but by the end of August it will rise about with the sun.

Mars has ceased to be an object of telescopic interest since its distance has increased to nearly 200 million miles. At the beginning of this period it will be an evening star, somewhat brighter than second magnitude, setting about four hours after the sun. It will be in conjunction with the moon on July 19 and on August 17.

Jupiter will be too near the sun in apparent position to be of interest during this period. Conjunction with the sun will occur on July 25.

Saturn will be an evening star of nearly first magnitude in eastern Sagittarius. During this period its apparent diameter will be about 16 seconds of arc, and its distance from the earth will be about 850 million miles. Its apparent motion among the stars will be retrograde. Conjunction with the moon will occur on July 1, July 28, and on August 24. Opposition will take place on July 13 and therefore Saturn will be on the meridian about midnight during the middle of July.

Uranus will be in the morning sky in eastern Pisces. Quadrature west of the sun will occur on July 12. Its apparent diameter will be about 3½ seconds of arc, and its distance will be about 1800 million miles. During the middle of July it will be on the meridian about 6:00 A.M. Conjunction with the moon will occur on July 8, August 4, and August 31.

Neptune, in the constellation Leo, will be approaching the sun in apparent position. Conjunction with the sun will occur on August 29. It will be remembered, however, that early in July it will be still nearly four hours behind the sun.

OCCULTATIONS

OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′.
(Contributed by the office of the *American Ephemeris*.)

Date 1931		Star	Mag.	IMMERSION Greenwich C.T. h m	IMMERSION a m	IMMERSION b m	IMMERSION Angle E from N °	EMERSION Greenwich C.T. h m	EMERSION a m	EMERSION b m	EMERSION Angle E from N °
July	2	56 B.Cap	6.3	4 12.6	—1.6	+2.2	31	5 15.4	—2.0	+0.2	295
	21	319 B.Vir	6.3	2 18.3	—0.7	—0.8	63	2 52.8	—0.3	—2.6	354
	28	234 B.Sgr	5.9	2 33.3	—1.9	+1.1	61	3 56.3	—2.1	—0.2	277
Aug.	4	171 B.Psc	6.3	7 59.6	—2.6	+0.6	91	9 2.4	—0.3	+2.9	186
	6	27 Ari	6.4	10 18.8	..	..	358	11 4.0	..	..	293
	7	ζ Ari	4.8	6 12.6	—0.3	+1.8	71	7 16.4	—0.4	+2.0	231
	8	36 Tau	5.6	5 7.6	..	..	143	5 22.3	..	..	175
	11	47 Gem	5.6	8 29.4	—0.6	—0.1	139	9 5.2	+0.6	+2.7	219
	15	89 Leo	5.7	23 57.5	—0.2	—1.7	130	0 58.8	+0.1	—1.6	291
	19	47 G.Lib	6.1	22 24.2	—1.9	—0.4	100	23 40.6	—1.5	—1.4	313
	21	65 B.Sco	5.5	0 47.0	—1.7	—0.8	93	2 4.2	—1.4	—1.6	291
	22	*W* Sgr var	4.3	23 18.1	—1.6	+0.3	116	0 37.5	—2.1	+0.4	252
	24	183 B.Sgr	6.2	1 32.4	—2.1	+0.1	91	2 56.3	—1.7	—0.1	244
	30	80 B.Psc	6.3	8 42.6	—1.8	—1.1	89	9 44.8	—0.4	+1.6	197
	31	147 B.Psc	5.9	9 56.2	..	..	135	10 14.5	..	..	158

OCCULTATIONS VISIBLE IN LONGITUDE +91°, LATITUDE +40°.

July	1	ω Sgr	4.8	9 59.7	—0.9	—0.2	57	11 9.4	—0.8	—0.9	256
	2	56 B.Cap	6.3	3 40.2	—1.2	+2.3	46	4 43.5	—1.1	+0.8	290
	8	ζ Psc	5.3	7 4.6	..	..	141	7 7.8	..	..	153
	10	36 Ari	6.5	6 51.4	—0.1	+0.3	128	7 13.8	+0.9	+2.8	179
	10	40 Ari	6.0	9 0.9	..	..	131	9 19.3	..	..	166
	13	107 B.Aur	6.5	9 44.2	+0.5	+1.6	58	10 35.8	—0.2	+1.0	275
	18	34 Leo	6.4	2 36.0	+0.7	—2.7	183	2 57.7	—0.1	—0.3	234

Occultations Visible in Longitude +91°, Latitude +40°—Continued.

Date 1931		Star	Mag.	Immersion Greenwich C.T. h m	Immersion a m	Immersion b m	Immersion Angle E from N °	Emersion Greenwich C.T. h m	Emersion a m	Emersion b m	Emersion Angle E from N °
	19	χ Leo	4.6	2 2.4	—0.5	—1.3	94	2 52.8	+0.1	—2.0	329
	21	319 B.Vir	6.3	1 59.5	—1.4	—1.0	83	2 52.0	—0.5	—2.4	342
	28	234 B.Sgr	5.9	1 57.4	—1.5	+1.5	75	3 17.4	—1.7	+0.6	277
Aug.	4	171 B.Psc	6.3	7 23.3	—1.2	+2.0	60	8 41.5	—1.1	+2.1	220
	7	ξ Ari	4.8	6 9.3	+0.3	+1.7	55	7 6.3	—0.1	+1.6	252
	11	47 Gem	5.6	8 25.8	+0.2	+0.5	117	9 10.3	+0.5	+1.6	241
	21	65 B.Sco	5.5	0 12.2	—2.0	—0.3	107	1 36.5	—1.9	—1.0	291
	22	*W* Sgr var	4.3	23 0.5	—0.3	—0.4	146	23 54.0	—2.3	+1.8	233
	24	183 B.Sgr	6.2	0 55.0	—1.8	+0.8	96	2 19.8	—2.1	+0.6	253
	30	80 B.Psc	6.3	8 7.1	—1.8	+0.8	60	9 28.8	—1.1	+1.2	216
	31	147 B.Psc	5.9	9 4.6	—2.8	—0.7	94	10 7.0	—0.4	+2.8	187

Occultations Visible in Longitude +120°, Latitude +36°.

July	1	ω Sgr	4.8	9 26.9	..	..	16	10 20.2	..	..	303
	1	A Sgr	4.9	11 6.3	—1.4	0.0	61	12 23.4	—1.1	—0.5	249
	4	182 B.Aqr	6.2	12 49.8	+0.6	+3.2	354	13 37.1	—3.4	—2.1	285
	10	40 Ari	6.0	8 44.9	+0.3	+1.0	98	9 28.5	+0.5	+2.0	208
Aug.	4	171 B.Psc	6.3	6 59.4	—0.1	+2.2	34	8 1.1	—0.8	+1.5	258
	11	134 B.Gem	6.5	10 34.9	0.0	0.0	130	11 13.0	+0.8	+1.9	228
	26	χ Cap	5.3	9 27.3	—0.6	+0.6	38	10 35.1	—0.9	—0.8	256
	30	80 B.Psc	6.3	7 24.6	—0.4	+2.9	9	8 31.0	—2.7	+0.6	268
	31	147 B.Psc	5.9	8 2.7	—1.1	+2.3	39	9 26.2	—1.7	+1.6	235

The quantities in the columns *a* **and** *b* **are given for the purpose of making** these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

VARIABLE STARS

Monthly Report of the American Association of Variable Star Observers for April, 1931.

We welcome initial reports to these columns from Prof. C. P. Olivier of the Flower Observatory; Mr. S. L. O'Byrne of Webster Groves, Missouri; Mr. Charles Weatherbee of Twin Falls, Montana; and Messrs. Arthur Winne and P. A. Cole of the Johns Hopkins University.

Also, after a long period of inactivity, a commendable report comes in from Mr. Michael Ebert, now a graduate student at Johns Hopkins University.

Mr. H. E. Houghton, one of our contributors from South Africa, will spend the next six months or more in England, and accordingly his observations will be sadly missed in these reports.

After an interval of more than a year during which time U Geminorum had escaped observation at any maximum, this variable was found to be rising to

Variable Star Observations Received During April, 1931.

Feb. 0 = J.D. 2426373; Mar. 0 = J.D. 2426401; Apr. 0 = J.D. 2426432.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
V Scl	T Cas	α Cas	W Cas	Y And	T Per
000339	001755	003656	004958	013338	021258
388 12.0 Bl	436 10.1 Mc	433 2.5 Oy	425 8.7 Jo	394 13.8 Ch	441 8.7 Me
395 11.3 Bl	436 10.0 Jo	436 2.3 Mc	426 9.6 BL	X Cas	443 8.8 BL
S Scl	439 10.3 Mc	437 2.3 Mc	427 9.4 Ah	014958	Z Cep
001032	440 9.4 Wr	439 2.4 Mc	431 9.5 Ah	394 12.6 Bn	021281
379 10.5 En	445 10.2 Mc	441 2.3 Mc	436 9.2 Jo	409 12.8 Bn	413[12.5 Mp
380 10.5 Ht	448 10.3 Mc	442 2.4 Mc	436 9.5 Pc	412 12.0 B	426[14.4 Br
382 10.2 Sm	R And	444 2.5 Mc	438 9.2 Fd	413 12.2 Mp	436[12.5 Pc
388 10.8 Bl	001838	445 2.4 Mc	U Tuc	415 12.6 Bn	o Cet
395 11.0 Bl	375 7.4 Ch	446 2.5 Mc	*005475*	415 12.0 Jo	*021403*
X And	394 8.4 Ch	447 2.6 Mc	379 11.0 En	418 12.6 Pt	375 9.5 Ch
001046	403 8.6 Ah	448 2.5 Mc	380 10.8 Ht	419 12.2 Jo	379 9.2 En
378[13.4 Ch	405 8.8 Ah	449 2.4 Mc	385 10.5 Ht	422 12.0 Jo	380 8.9 Sl
T Cet	406 8.9 Ah	U Cas	385 10.8 Sm	425 12.0 Jo	386 8.8 Sl
001620	406 8.8 Ch	004047	386 10.5 En	443 12.4 Bn	386 9.2 En
379 6.2 Kd	407 9.1 Ah	380 8.7 Ch	388 10.0 Bl	449 12.4 Bn	393 9.2 Ch
T And	414 9.3 Ah	406 10.3 Md	390 10.1 Ht	U Per	400 8.3 Sl
001726	415 9.2 Ch	418 10.7 Pt	394 9.5 Sm	015254	403 9.1 Ah
378 8.8 Ch	417 9.4 Ah	RW And	395 9.7 Bl	379 8.4 Ch	406 9.2 Ah
396 9.0 Ch	418 9.2 Pt	004132	398 9.5 Ht	418 9.6 Pt	407 9.2 Ah
407 9.3 Ch	419 9.4 Wd	380 11.4 Ch	398 9.2 Dr	419 10.5 Jo	410 8.9 Ch
T Cas	419 9.4 Ah	V And	415 8.3 Dr	420 10.2 Me	411 7.9 Sl
001755	427 9.5 Ah	004435	425 8.5 Dr	420 10.3 Ch	418 8.4 Pt
375 7.5 Ch	S Tuc	380[13.1 Ch	U Scl	421 10.2 BL	419 7.5 Sl
393 8.3 Ch	*001862*	X Scl	*010630*	422 10.4 Jo	425 7.0 Sl
403 8.5 Ah	379[13.2 En	*004435*	388 10.6 Bl	426 10.4 BL	S Per
405 8.6 Ah	382[12.4 Sm	383[13.6 Bl	395 9.9 Bl	436 10.6 Me	021558
406 8.5 Ah	385[13.2 Ht	RR And	U And	437 9.7 Mc	407 9.4 Ah
406 8.7 Ch	388[13.2 Bl	004533	010940	438 10.8 Fd	414 9.6 Ah
407 8.6 Wr	390[13.2 Sm	380 9.7 Ch	380 11.8 Ch	XX Per	414 9.6 B
407 9.0 Th	398[13.2 Dr	RV Cas	UZ And	015654	415 9.3 Sz
407 8.6 Ah	T Scl	004746a	011041	379 8.3 Ch	418 9.4 Pt
408 8.6 Ah	*002438a*	380 11.6 Ch	380 12.6 Ch	420 8.0 Ch	421 9.4 Me
409 9.2 Th	379 10.5 En	418 11.2 Pt	S Cas	R Ari	421 10.0 BL
410 9.0 Th	398 9.5 Dr	— Cas	011272	021024	422 9.2 Bg
410 7.9 Mp	T Phe	004746b	380[13.0 Ch	377 9.1 Ch	426 9.7 BL
412 9.2 Th	*002546*	418 10.6 Pt	417[10.5 Th	396 10.0 Ch	427 9.5 Ah
413 8.8 Ah	379 12.0 En	W Cas	445 13.0 Bg	418 12.4 Pt	431 9.2 Bg
414 9.4 Th	380 12.2 Ht	004958	U Psc	419 12.0 Al	438 9.2 Fd
414 8.6 Wr	382 11.3 Sm	380 8.4 Ch	011712	420 12.1 Ch	441 9.5 Me
414 8.6 Ah	386 10.6 En	403 9.1 Ch	394 12.8 Ch	W And	443 9.3 Sz
415 8.9 Ah	388 10.3 Bl	405 9.2 Ah	R Scl	021143a	443 9.4 Bg
415 9.6 Th	390 10.1 Sm	406 9.3 Ah	*012233a*	420 12.1 Ch	443 9.6 BL
415 8.2 Jo	395 9.8 Bl	407 9.2 Ah	379 7.8 Kd	437 11.4 Gy	R Cet
417 9.8 Th	398 9.6 Dr	408 9.2 Ah	RZ Per	T Per	*022000*
417 8.9 Ah	W Scl	413 9.4 Ah	012350	021258	386 9.1 Ch
418 8.9 Ah	*002833*	414 9.3 Ah	379 10.6 Ch	407 8.8 Ah	393 10.0 Ch
418 9.2 Pt	388 13.1 Bl	415 9.4 Ah	412 12.1 Ch	414 8.7 Ah	396 10.5 Ch
418 10.0 Th	α Cas	415 8.5 Jo	413 12.1 Mp	415 8.3 Jo	407 11.2 Ch
419 9.0 Ah	003656	417 9.3 Ah	RU And	418 8.7 Pt	RR Per
419 8.7 Jo	411 2.3 Oy	418 9.0 Pt	013238	419 8.4 Jo	022150
420 9.0 Ah	416 2.5 Oy	418 9.4 Ah	378 10.4 Ch	419 8.7 Ah	379 13.3 Ch
421 8.6 Mp	425 2.6 Mc	419 9.4 Ah	394 10.9 Ch	421 8.8 Me	420[11.3 Ch
422 9.0 Jo	428 2.5 Mc	419 8.6 Jo	412 11.1 Ch	421 8.6 BL	R For
425 9.0 Jo	429 2.2 Mc	420 9.4 Ah	418 11.8 Pt	422 8.3 Jo	*022426*
427 9.1 Ah	430 2.3 Mc	421 9.5 BL	Y And	426 8.7 BL	389 9.0 Bl
427 10.2 Th	431 2.4 Mc	421 8.6 Pc	013338	427 8.3 Jo	395 8.6 Bl
431 9.2 Ah	432 2.5 Mc	422 8.7 Jo	378 13.3 Ch	427 8.7 Ah	

VARIABLE STAR OBSERVATIONS RECEIVED DURING APRIL, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
U CET	R HOR	Y PER	W TAU	R DOR	R ORI
022813	*025050*	032043	042215	*043562*	045307
378 11.0 Ch	380 11.5 Ht	427 10.9 Jo	423 10.0 Fd	385 5.6 Sm	412 11.1 Ch
393 9.6 Ch	382 10.6 Sm	427 10.8 Ah	426 9.4 Ws	385 5.4 Ht	412 11.2 B
408 8.9 Ch	385 11.4 Ht	435 10.8 Me	427 9.3 Jo	386 5.6 En	419 11.5 Mg
415 8.4 Ch	386 10.3 En	441 10.7 Me	438 9.6 Fd	389 5.6 Bl	426 11.7 B
RR CEP	386 10.3 Sl	R PER	447 10.0 Bw	390 5.4 Sl	R LEP
022980	389 10.6 Bl	032335	S TAU	390 5.4 Ht	*045514*
413 12.5 Mp	390 10.9 Ht	379 12.8 Ch	042309	394 5.6 Sm	377 6.0 Ch
418 11.7 Pt	390 10.6 Sm	388 12.3 Ch	379[12.0 Ch	396 5.8 Bl	380 5.5 Sl
421 11.8 Pc	395 10.1 Sl	406 11.8 Md	412[13.8 B	398 5.4 Dr	390 5.6 Sl
426 12.3 Br	396 10.5 Bl	412 11.0 Ch	T CAM	398 5.2 Ht	394 7.0 Ch
436 12.7 Pc	398 10.8 Ht	414 10.7 B	043065	410 5.4 Sl	406 6.5 Bc
R TRI	398 9.9 Dr	417 10.7 Md	379 13.7 Ch	415 5.3 Dr	410 5.6 Sl
023133	399 10.2 En	418 10.7 Pt	418 13.5 Pt	418 5.2 Sl	412 6.5 Ch
378 11.4 Ch	400 9.8 Sl	419 10.6 Mg	S RET	425 5.2 Sl	415 6.5 Jo
393 11.6 Ch	415 9.0 Dr	420 9.6 Ch	*043163*	425 5.1 Dr	418 6.8 Pt
406 11.5 Ah	418 8.7 Sl	421 10.1 Pc	398 11.2 Dr	R CAE	419 6.7 Jo
407 11.8 Ah	425 8.4 Sl	424 9.9 Ma	415 11.2 Dr	*043738*	419 5.7 Sl
408 11.8 Ah	425 8.8 Dr	436 9.2 Pc	425 11.7 Dr	380 11.6 En	420 6.4 Ch
410 11.6 Ch	T HOR	439 9.3 B	RX TAU	382 11.7 Ht	421 7.0 Me
414 11.8 Ah	*025751*	439 9.1 Mg	043208	385 11.7 Sm	422 6.6 Jo
415 11.5 Jo	379 10.9 En	U ERI	379 13.7 Ch	386 11.8 En	424 6.4 Ch
417 11.6 Ah	380 11.0 Ht	*034625*	412 13.8 Ch	388 11.7 Ht	425 5.7 Sl
418 11.3 Sf	382 11.6 Sm	385 10.7 Sm	419 13.8 B	389 11.5 Bl	425 6.8 Jo
418 11.9 Wd	385 11.6 Ht	386 10.6 En	R RET	394 11.8 Sm	V ORI
418 11.8 Pt	386 11.8 En	394 10.8 Sm	*043263*	396 11.7 Bl	050003
419 11.5 Jo	389 11.7 Bl	398 10.4 Dr	379 7.2 Sl	398 12.0 Ht	380 13.4 Ch
419 11.5 Ah	390 12.0 Ht	415 10.4 Dr	380 7.6 En	413 12.7 Dw	412[14.0 B
422 11.8 Wd	390 12.0 Sm	425 11.0 Dr	380 7.6 Ht	413 13.0 Dr	418 13.5 Pt
422 11.6 Jo	396 12.2 Bl	T ERI	385 7.6 Ht	425 13.6 Dr	419[12.8 Mg
425 11.9 Jo	398 12.3 Ht	*035124*	385 7.5 Sm	R PIC	423[12.3 Md
427 11.7 Wd	398 12.4 Dr	379 10.8 En	386 7.6 En	*043349*	T LEP
T ARI	399 12.2 En	385 10.0 Sm	389 7.4 Bl	380 7.8 En	*050022*
024217	415 13.0 Dr	386 10.0 En	390 7.5 Ht	382 8.5 Ht	380 8.0 En
435 9.5 Me	425 13.2 Dr	394 9.6 Sm	390 7.4 Sl	385 8.7 Sm	385 8.8 Sm
W PER	U ARI	398 9.0 Dr	394 8.3 Sm	386 8.0 En	386 8.0 En
024356	030514	415 8.1 Dr	395 7.5 Sl	388 8.4 Ht	389 8.7 Bl
378 8.4 Ch	394 13.5 Ch	425 8.0 Dr	396 7.5 Bl	389 9.1 Bl	394 8.9 Sm
394 8.5 Ch	420 13.4 Ch	W ERI	398 7.7 Ht	394 9.0 Sm	396 8.7 Bl
411 9.2 Bw	X CET	*040725*	398 7.9 Dr	396 8.8 Bl	399 8.1 En
414 8.9 B	*031401*	398 8.7 Dr	410 8.1 Sl	398 8.5 Ht	414 9.5 B
415 8.6 Jo	378 11.5 Ch	415 9.3 Dr	415 9.0 Dr	398 8.3 Dr	415 9.2 Jo
418 9.0 Pt	418 12.1 Pt	425 9.7 Dr	418 8.9 Sl	399 8.2 En	418 9.3 Pt
419 8.5 Jo	Y PER	R TAU	425 9.3 Sl	415 8.1 Dr	419 9.4 Jo
420 9.2 Ch	032043	042209	425 9.3 Dr	425 7.9 Dr	422 9.8 Jo
421 9.1 Me	379 9.6 Ch	379[12.0 Ch	X CAM	V TAU	425 9.9 Jo
422 8.5 Jo	394 9.8 Ch	412[13.8 B	043274	044617	S PIC
427 8.6 Jo	407 10.7 Ah	443[12.0 Bg	380 9.2 Ch	380 13.3 Ch	*050848*
431 9.0 Bg	413 10.7 Ah	W TAU	412 9.0 Ch	408 10.9 Ch	380 8.2 En
436 8.8 Me	415 10.8 Ah	042215	418 9.5 Pt	412 11.0 B	382 8.3 Ht
437 10.0 Mc	415 10.5 Jo	379 9.8 Ch	421 9.3 Pc	418 11.0 Pt	385 8.8 Sm
438 9.2 Me	417 10.8 Ah	405 9.5 Ws	424 9.6 Ch	419 10.3 Mg	386 8.4 En
441 9.0 Me	418 10.1 Pt	412 10.2 Ch	424 9.2 B	424 10.0 Ch	388 8.8 Ht
443 8.9 Bg	419 10.8 Jo	412 10.5 B	444 10.6 GD	439 9.1 B	389 8.4 Bl
447 9.7 Mc	419 10.8 Ah	415 9.7 Jo	R DOR	439 9.2 Mg	394 9.0 Sm
448 9.2 Bw	420 11.1 Ch	418 9.9 Pt	*043562*	R ORI	396 8.6 Bl
R HOR	421 10.6 BL	419 9.7 Jo	380 5.7 Sl	045307	398 8.9 Ht
025050	422 10.8 Jo	419 10.2 Al	380 5.5 En	380 10.3 Ch	398 8.7 Dr
379 10.9 En	426 10.8 BL	422 9.6 Jo	380 5.5 Ht	406 11.5 Md	399 9.1 En

VARIABLE STAR OBSERVATIONS RECEIVED DURING APRIL, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
S PIC	S AUR	T ORI	U AUR	R COL	U ORI
050848	052034	*053005a*	053531	*054629*	054920a
425 9.6 Dr	424 8.7 Ch	417 11.0 Br	418 7.7 Ah	380 13.0 En	444 10.1 Fd
R AUR	436 10.3 Mc	419 10.1 Jo	419 7.7 Ah	385[12.4 Sm	444 9.9 GD
050953	438 9.0 B	420 11.5 Ch	420 7.7 Ah	389[13.0 Bl	446 9.2 Al
303 11.1 Wb	438 9.0 Fd	422 10.5 Jo	426 7.2 B	398[13.0 Ht	UW ORI
303 11.0 Eb	439 10.4 Mc	423 10.7 Pt	427 7.5 Ah	413 14.1 Dr	054920b
303 11.3 Co	444 9.0 Fd	423 11.0 Ch	428 7.6 Ah	413 14.3 Dw	438 10.7 Fd
319 11.7 Wb	444 9.0 Pc	423 10.7 Fd	431 7.6 Ah	α ORI	V GEM
319 11.7 Co	445 10.3 Mc	426 11.2 B	432 7.5 Ah	054907	054974
319 9.5 We	447 10.4 Mc	426 11.0 Br	440 7.7 Sf	383 0.1 Sl	394[13.6 Ch
333 10.5 We	448 10.5 Mc	426 10.4 Ws	445 8.0 Sf	390 0.1 Sl	Z AUR
348 10.6 We	W AUR	427 10.6 Jo	SU TAU	395 0.1 Sl	055353
363 11.2 We	052036	434 10.7 Pt	054319	410 0.2 Sl	412 10.7 B
380 13.2 Ch	380 13.2 Ch	438 11.2 Pt	378 12.8 Ch	419 0.1 Sl	419 10.6 Al
387 13.3 Ch	412 10.1 B	438 10.1 Fd	394 11.8 Ch	433 0.6 Oy	423 10.6 Pt
410 13.0 We	412 9.9 Ch	438 11.1 B	396 11.5 Ch	436 0.5 Mc	434 10.6 Pt
418 13.2 Pt	418 9.5 Sf	441 10.5 Pt	412 11.3 Ch	439 0.6 Mc	435 10.0 Me
423 13.6 We	418 9.6 Pt	442 10.5 Pt	413 11.4 Br	445 0.6 Mc	436 10.5 Pt
424 13.3 Ch	419 9.5 Jo	S CAM	414 11.3 Br	449 0.9 Oy	437 10.3 Pt
T PIC	419 10.2 Mg	053068	414 11.5 B	454 0.7 Oy	437 10.1 Me
051247	421 9.3 BL	394 8.4 Ch	417 11.5 Br	U ORI	438 10.3 Fd
380 11.8 En	422 9.0 Jo	405 8.7 Ws	418 11.6 Sf	054920a	438 10.2 Pt
382 12.5 Ht	426 9.2 BL	412 8.7 Ch	419 11.5 B	378 8.1 Ch	439 10.2 Pt
385 12.2 Sm	439 9.1 B	418 9.6 Pt	421 11.5 Pc	380 7.8 Sl	439 9.7 B
386 11.8 En	439 9.4 Mg	419 10.2 Bg	423 11.7 Pt	386 7.9 Sl	439 10.7 Mc
388 11.5 Ht	440 9.4 Sf	421 8.8 BL	424 11.0 Ch	390 8.0 Sl	440 9.8 Me
389 11.6 Bl	441 9.1 BL	421 8.9 Pc	424 11.6 Ma	395 8.2 Sl	441 10.2 Pt
394 11.8 Sm	443 9.2 BL	426 9.0 BL	426 12.0 B	395 8.6 Ch	442 10.2 Pt
396 11.0 Bl	445 9.5 Sf	431 9.6 Bg	432 11.5 Br	397 8.5 Kd	443 9.7 Pc
398 11.0 Ht	445 9.4 Ma	441 9.3 BL	434 11.5 Br	403 9.0 Ah	443 9.7 Fd
415 9.6 Dr	S ORI	443 9.6 Bg	436 11.7 Pc	405 9.0 Ws	443 10.2 Pt
425 9.6 Dr	*052404*	443 9.3 BL	436 11.8 Pt	406 9.1 Ah	444 10.2 Pt
T COL	378 12.6 Ch	RR TAU	438 11.9 B	407 8.9 Ah	446 9.2 Al
051533	412 12.3 Ch	053326	438 11.8 Pt	412 9.2 Ch	447 10.8 Mc
380 7.7 En	412 11.7 B	412 13.4 B	439 12.0 Pt	413 9.2 Ah	R OCT
382 8.1 Ht	418 13.1 Pt	RV AUR	439 12.0 Mg	414 9.2 Ah	055686
385 8.4 Sm	419 11.9 Al	053337	441 11.7 Pt	415 9.2 Ah	396 12.3 Bl
386 8.2 En	419 12.4 Mg	319 12.5 Eb	442 11.9 Pt	415 8.8 Jo	413 12.8 Dr
388 8.4 Ht	424 12.1 Ch	319 12.5 Co	444 10.7 Fd	417 9.1 Ah	413 12.5 Dw
389 8.4 Bl	426 11.0 B	412[13.4 Ch	444 11.0 Pc	418 9.0 Wd	415 12.6 Dw
394 8.7 Sm	439 11.7 Mg	418[12.0 Pt	S COL	418 9.3 Pt	425 12.6 Dr
396 8.3 Bl	446 11.4 Al	421[12.3 Pc	*054331*	419 9.2 Al	X AUR
398 9.0 Ht	T ORI	439[12.4 Mg	380[13.1 En	419 8.6 Sl	060450
399 8.4 En	*053005a*	U AUR	385[12.6 Sm	419 9.0 Jo	378 8.7 Ch
415 9.7 Dr	303 10.9 Wq	053531	389[13.1 Bl	419 9.3 Ah	394 8.8 Ch
425 9.7 Dr	303 11.1 Eb	380 11.2 Ch	398[13.1 Ht	422 10.2 Kd	414 8.8 Ch
S AUR	304 10.9 Co	403 8.7 Ah	413 14.2 Dr	422 9.2 B	418 8.9 Pt
052034	319 10.0 Co	405 8.6 Ah	413 14.3 Dw	422 9.1 Wd	418 9.2 Sf
319 9.1 Eb	319 10.2 Eb	406 8.6 Ah	Z TAU	422 8.9 Jo	419 9.7 Al
319 9.0 Co	378 10.8 Ch	407 8.3 Ah	054615a	423 9.1 Fd	421 9.3 Pc
380 8.8 Ch	379 10.8 Ch	408 8.2 Ah	394 13.0 Ch	425 8.9 Jo	423 9.0 Ch
394 8.5 Ch	387 10.8 Ch	412 7.4 Ch	420 13.2 Ch	425 8.9 Sl	424 9.3 B
395 8.5 Ch	388 10.5 Ch	413 7.9 Ah	424 13.0 Ma	427 9.0 Wd	426 9.3 Ch
412 8.7 Ch	394 10.5 Ch	414 7.8 Ah	RU TAU	427 9.4 Ah	436 9.9 Pc
415 8.5 Jo	395 10.3 Ch	415 7.8 Ah	054615c	438 10.2 Fd	443 10.4 Sf
418 8.6 Pt	396 10.2 Ch	416 7.8 Ah	394 12.0 Ch	439 10.2 Mc	446 11.2 Al
419 8.9 Jo	405 10.1 Ws	417 7.7 Ah	420 12.6 Ch	439 10.0 GD	V AUR
422 8.9 Jo	412 11.4 Ch	418 7.7 Pt	424 12.7 Ma	440 9.9 Wd	061647
423 9.1 Fd	415 10.0 Jo	418 7.8 Sf		444 10.2 Pc	394 11.0 Ch

VARIABLE STAR OBSERVATIONS RECEIVED DURING APRIL, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
V AUR	X GEM	R GEM	R VOL	Z PUP	U PUP
061647	064030	070122a	*070772*	*072820b*	*075612*
419 10.8 Ch	440 12.6 Bw	413 9.5 Ah	380 10.1 Ht	393 11.0 En	441 11.7 Bw
419 10.3 B	443 12.2 Bn	414 9.5 Ah	385 10.4 Ht	S VOL	448 11.1 Bw
439 10.1 B	443 12.3 Mg	415 9.5 Ah	386 10.6 En	*073173*	R CNC
439 10.6 Mg	445 12.7 Ma	415 8.8 Jo	390 10.1 Ht	386 12.8 En	081112
447 10.5 Mc	448 12.9 Bw	417 9.6 Ah	393 10.2 En	390 12.5 Ht	392 9.5 Ch
V MON	449 12.8 Bn	418 9.8 Ah	398 9.8 Dw	390 13.0 Bl	403 9.6 Ah
061702	Y MON	418 9.6 Wd	398 10.2 Ht	390 12.5 Sm	405 9.5 Ah
388 13.0 Ch	065111	418 9.0 Bg	415 9.7 Dr	393 12.4 En	406 9.6 Ah
418 12.8 Pt	388 10.6 Ch	419 9.3 Ch	425 9.9 Dr	396 12.0 Bl	407 9.5 Ah
419 12.9 Ch	414 12.4 Br	419 9.0 Jo	L_2 PUP	398 12.0 Ht	407 8.9 Ch
424 12.3 Al	418 12.1 Pt	419 9.8 Ah	*071044*	398 12.1 Dw	408 9.4 Ah
443 12.1 Mg	418 12.7 Bg	421 9.9 Ah	380 4.0 Sl	415 12.1 Dr	413 9.3 Ah
U LYN	419 12.5 Ch	421 9.7 Me	383 4.0 Sl	425 11.1 Dr	414 9.1 Ah
063159	424 12.6 Ma	422 9.2 Jo	386 4.0 Sl	U CMI	416 9.2 Ah
438 9.9 B	439 13.3 B	422 9.6 Wd	390 4.0 Sl	073508	416 8.7 Jo
R MON	443 13.6 Bg	423 10.1 Pt	395 3.9 Sl	388 9.6 Ch	417 8.9 Ah
063308	X MON	424 9.3 Al	410 4.3 Sl	414 11.0 Br	418 9.0 Ah
378 12.6 Ch	*065208*	427 9.6 Wd	412 4.5 Dr	416 10.8 Ch	418 9.0 Wd
379 12.6 Ch	410 8.0 Tf	427 9.8 Ah	415 4.9 Dr	419 11.0 Bg	419 8.9 Ah
387 12.6 Ch	415 7.2 Dr	430 9.8 Ch	418 4.8 Sl	423 11.2 Pt	420 8.9 Ah
388 12.6 Ch	416 7.0 Jo	431 9.3 Bg	422 5.4 Dr	427 11.4 Bg	421 8.9 Ah
394 12.6 Ch	419 7.0 Jo	432 9.9 Jo	425 5.4 Dr	431 11.4 Bg	421 9.2 Pc
395 12.6 Ch	422 7.2 Jo	432 9.3 Me	425 5.1 Sl	438 11.8 B	422 8.8 Jo
396 12.6 Ch	425 7.1 Dr	436 9.8 Me	RR MON	441 12.1 Bg	422 8.8 Wd
412 12.6 Ch	432 6.9 Tf	440 9.8 Wd	071201	S GEM	423 8.6 Pt
418 11.9 Pt	R LYN	443 10.0 Bg	442 11.6 Me	073723	424 8.6 Ch
419 12.4 Ch	065355	443 10.0 Wd	444 11.4 Sf	378 12.0 Ch	426 8.8 Ah
420 12.4 Ch	394 12.4 Ch	445 10.2 Al	V GEM	388 12.3 Ch	427 8.7 Ah
423 12.6 Ch	414 12.4 Br	445 10.3 Co	071713	419 13.0 B	427 8.8 Wd
424 12.6 Ch	424 12.5 Ma	445 10.4 Eb	388 8.8 Ch	423 13.4 Ch	428 8.6 Ah
438 12.0 B	424 13.7 Ch	445 10.4 Wq	414 9.0 Br	W PUP	432 8.4 Ah
Nov PIC	438 13.6 B	Z GEM	416 8.8 Ch	*074241*	436 8.3 Pc
063462	RS GEM	070122b	423 8.7 Pt	380 9.4 Ht	441 7.4 Wd
380 8.4 En	065530	423 12.6 Pt	S CMI	382 9.1 Sm	441 7.5 HS
380 8.3 Ht	424 12.0 Ma	445 12.2 Co	*072708*	385 9.0 Ht	443 7.3 Wd
385 8.4 Ht	445 11.0 Ma	445 12.3 Eb	378 11.8 Ch	387 8.8 En	444 7.2 Co
387 8.5 En	Z CMA	445 12.3 Wq	393 12.2 Ch	390 8.5 Sm	444 7.2 Eb
390 8.4 Sm	*065011*	TW GEM	406 12.1 Ke	390 8.7 Ht	444 7.0 Wq
393 8.5 En	380 10.0 Sl	070122c	413 12.2 Ke	390 8.2 Bl	445 7.2 HS
390 8.4 Ht	386 10.0 Sl	423 8.3 Pt	416 12.7 Ch	393 8.0 En	450 7.0 HS
398 8.3 Ht	390 10.0 Sl	445 8.3 Co	418 12.3 Ke	396 7.8 Bl	459 6.6 Oy
S LYN	410 9.9 Sl	445 8.5 Eb	421 12.3 Pc	398 8.2 Ht	460 6.8 Oy
063558	418 10.0 Sl	445 8.4 Wq	421 12.3 Ke	415 8.0 Dr	V CNC
394 13.4 Ch	425 9.8 Sl	R CMI	421 12.3 BL	425 8.6 Dr	081617
414 14.2 Br	V CMI	070310	423 12.2 Ke	T GEM	387 8.2 Ch
418 13.6 Pt	070109	388 10.1 Ch	423 12.0 Pt	074323	403 9.0 Ah
424 13.8 Ch	388 13.8 Ch	418 9.0 Sf	424 12.3 Al	378 10.9 Ch	405 9.1 Ah
440[13.1 Me	423[12.5 Md	419 8.9 Ch	431 12.0 Ke	388 11.2 Ch	406 9.2 Ah
X GEM	447[13.0 Bw	421 9.1 Pc	436 11.7 Pc	414 12.8 Br	406 8.9 Ke
064030	R GEM	425 8.8 Jo	438 12.0 B	422 13.2 Bg	407 9.1 Ah
394 9.5 Bn	070122a	432 8.7 Jo	438 11.9 Fd	423 13.3 Ke	408 9.2 Ah
409 10.3 Bn	377 7.8 Ch	436 9.0 Pc	T CMI	423 13.0 Ch	413 9.3 Ah
415 10.7 Bn	393 8.5 Ch	436 8.7 Me	*072811*	423 12.8 Pt	415 9.3 Ke
424 11.9 Ma	403 9.1 Ah	439 8.8 B	388[13.8 Ch	424 13.3 Ma	414 9.4 Ah
427 11.5 Bw	405 9.2 Ah	440 8.9 Sf	416[13.8 Ch	447[13.3 Bw	415 9.4 Ah
436 12.2 Bw	406 9.3 Ah	445 8.9 Sf	Z PUP	U PUP	417 9.6 Ah
436 12.2 Me	407 9.3 Ah		*072820b*	*075612*	418 9.8 Wd
439 12.2 B	408 9.1 Ah		387 11.0 En	427 12.3 Bw	419 9.6 Ah

VARIABLE STAR OBSERVATIONS RECEIVED DURING APRIL, 1931.

J.D.Est.Obs.

V CNC
081617
421 9.8 Ke
422 10.2 Wd
423 9.8 Pt
423 9.6 Ke
423 10.3 Fd
424 9.9 Ch
426 9.9 Ah
427 10.1 Ah
427 10.1 Wd
431 9.8 Ke
437 10.4 Gy
440 11.0 Me
443 11.5 Wd
447 11.3 Co
447 11.5 Eb
447 11.5 Wq

RT HYA
082405
414 8.6 Mp
418 8.9 Bg
423 8.4 Pt
426 8.6 Th
427 8.6 Th
427 8.2 Bg
431 7.9 Bg
438 8.0 Me
444 7.8 Bg

R CHA
082476
380 11.5 En
380 11.5 Ht
382 11.8 Sm
385 12.0 Ht
386 11.8 En
390 12.0 Sm
390 12.2 Ht
390 12.3 Bl
394 12.0 En
396 12.1 Bl
398 12.3 Ht

U CNC
083019
416 13.9 Ch
424[14.1 Ma
443[13.3 Bw
447[14.1 Ol
450[13.3 Bw

X UMA
083350
440 13.2 Me
445 12.7 Bg
452 12.0 Eb
452 12.1 Wq

S HYA
084803
387 11.4 Ch
396 11.5 Ch
423 12.1 Pt

J.D.Est.Obs.

S HYA
084803
424 12.1 Ch
438 11.7 Fd
441 11.3 Bg
447 11.2 Ol

T HYA
085008
387 7.8 Ch
396 8.1 Ch
407 8.5 Ch
423 9.0 Pt
423 9.0 Fd
424 9.2 Ch
438 10.1 Fd

T CNC
085120
387 10.0 Ch
416 9.6 Ch
421 10.1 BL
423 8.9 Pt
426 10.2 BL
441 9.6 BL
442 9.4 Me
443 9.7 BL
447 9.0 Ol
451 10.0 Co
451 9.9 Eb

T PYX
090031
390 [u Bl

V UMA
090151
418 10.6 Sf
443 10.6 Sf
447 10.7 Mc

U CNC
090425
387[13.6 Ch
416 14.0 Ch
423 13.8 Ke
427[10.4 Th
443[12.8 Md
447 13.1 Ol
447 13.2 Co
447 13.2 Eb
447 13.1 Wq

RW CAR
091868
390 13.4 Bl
396 13.2 Bl
411 12.4 Dw
414 12.3 Dr
414 12.7 Dw

Y VEL
092551
380 12.9 Ht
390 12.4 Sm
414 14.4 Dr
414 14.4 Dw

J.D.Est.Obs.

Y VEL
092551
415 14.5 Dw

R CAR
092062
380 9.2 Ht
382 9.2 Sm
385 9.2 Ht
386 8.8 Sl
387 9.6 En
390 9.2 Sm
390 8.9 Sl
390 9.4 Ht
390 9.1 Bl
394 9.4 En
395 9.0 Sl
396 9.5 Bl
398 9.5 Ht
398 9.5 Dw
415 9.4 Dr
418 9.9 Sl
425 9.6 Dr
426 9.9 Sl

X HYA
093014
385 9.4 Ch
394 9.5 Ch
408 10.0 Ch
418 10.3 Wd
423 10.3 Pt
426 10.3 B
431 10.3 Bg
438 10.6 Fd
441 11.2 Bg
441 10.9 Me

Y DRA
093178
394 14.0 Ch
416[13.9 Ch

R LMI
093934
387 11.9 Ch
394 11.8 Ch
406 11.9 Ke
413 11.7 Ke
413 11.7 Ah
414 11.7 Ah
416 11.3 Ah
416 10.9 Ch
417 11.6 Ah
418 11.6 Ah
419 11.5 Ah
421 11.5 Ke
423 11.4 Ke
423 11.3 Pt
424 11.4 B
424 11.4 Al
427 11.1 Ah
442 10.0 Me
443 10.6 HS

J.D.Est.Obs.

R LMI
093934
443 10.2 Sz
443 10.7 Fd
443 10.7 Pc
445 10.9 HS
450 10.5 HS
451 10.1 Co
451 10.3 Eb

RR HYA
094023
393 13.2 En
415 13.0 Dr
422 13.0 Kd
425 12.9 Dr

R LEO
094211
385 8.9 Ch
393 8.4 Ch
403 8.1 Ah
405 8.1 Ah
406 8.1 Ah
407 8.1 Ah
407 8.3 Ch
408 8.1 Ah
410 8.1 Tf
413 8.0 Ah
414 7.8 Ah
415 7.9 Ah
415 7.3 Jo
415 7.4 Sz
416 7.9 Ah
417 7.6 Ah
418 7.5 Ah
418 7.5 Wd
418 8.1 Sf
419 7.3 Ah
419 7.3 Jo
420 7.2 Ah
421 7.2 Me
421 7.2 Ah
421 7.7 BL
421 7.4 Pc
422 7.1 Kd
422 7.4 Wd
422 7.1 Jo
423 6.5 Pt
423 7.2 Tf
424 7.1 Ah
424 6.5 Ma
426 6.9 Ah
426 6.6 BL
427 6.8 Ah
427 6.7 Bg
427 7.5 Sf
427 7.3 Wd
428 6.8 Ah
429 7.3 Kd
430 6.9 Ch
432 6.4 Me

J.D.Est.Obs.

R LEO
094211
432 6.3 Ah
433 6.7 Oy
435 6.1 Me
436 6.2 Mc
436 5.8 Pc
437 6.0 Me
438 5.9 Me
439 6.3 Mc
440 5.7 Oy
440 6.0 Me
440 6.3 Sf
440 6.2 Wd
441 5.8 Me
441 6.2 HS
441 5.8 BL
442 5.6 Oy
442 5.5 Pc
442 5.6 Me
443 5.9 Sz
443 5.7 BL
443 5.7 Wd
444 5.5 Bg
445 6.0 Mc
445 5.8 HS
445 5.7 Ma
445 6.2 Sf
446 5.5 Al
447 5.6 Oy
447 6.2 Mc
447 5.7 HS
448 6.4 Mc
450 5.7 Oy
451 5.6 Eb
451 5.5 Co
454 5.5 Oy
458 5.7 Oy
460 5.6 Oy

1 CAR
094262
410 3.8 Sl
415 3.4 Dr
418 3.4 Sl
419 3.5 Sl
425 3.7 Dr
426 3.6 Sl

Y HYA
094622
387 7.2 En
394 8.0 En
396 7.8 Kd
416 7.2 Ch
423 6.6 Pt

Z VEL
094953
410 5.4 Sl
415 5.3 Dr
418 5.4 Sl
423 5.2 Dr
426 5.4 Sl

J.D.Est.Obs.

Z VEL
094953
387 11.8 En
390 12.1 Ht
390 11.9 Sm
390 11.4 Bl
394 11.9 En
396 11.6 Bl
398 12.3 Ht
414 11.8 Dw
414 11.7 Dr
415 12.0 Dw

V LEO
095421
387 13.0 Ch
416 13.6 Ch
421 13.3 Ke
423 13.4 Ke
423 13.5 Pt
424 13.4 B
424 13.0 Ma
447 13.5 Ol

RR CAR
095458
380 8.1 Ht
385 8.0 Ht
387 7.9 En
390 8.2 Ht
394 8.2 En
398 8.0 Ht

RV CAR
095563
380[13.1 Ht
390[13.1 Bl
394 12.6 En
414 13.1 Dr
414 13.2 Dw

R ANT
100537
415 7.4 Dr

S CAR
100661
380 5.8 Sl
380 5.8 Ht
382 6.2 Sm
385 5.8 Ht
388 6.0 En
390 6.3 Sm
390 5.8 Ht
390 5.7 Bl
395 5.6 Sl
394 6.0 En
396 5.5 Bl
398 5.5 Ht
400 5.4 Sl
410 5.4 Sl
415 5.3 Dr
418 5.4 Sl
423 5.2 Dr
426 5.4 Sl

VARIABLE STAR OBSERVATIONS RECEIVED DURING APRIL, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
U UMa	R UMa	RS Cen	SU Vir	U Cen	R Vir
100860	103769	*111661*	120012	*122854*	123307
385 6.5 Ch	424 12.5 Ch	390 10.3 Sm	447 11.7 Ol	396 12.2 Bl	423 7.2 Pt
408 6.8 Ch	424 12.6 Wd	390 10.6 Bl	448 11.6 Bw	T UMa	424 7.3 Ma
Z Car	444 12.7 Gy	390 10.5 Ht	T Vir	123160	424 7.4 Ah
101058a	V Hya	394 11.0 En	*120905*	385 7.6 Ch	426 7.4 Ah
380 12.0 Ht	*104620*	396 10.7 Bl	421 12.1 Pc	403 8.1 Ah	427 7.5 Ah
382 11.4 Sm	385 8.2 Ch	398 11.2 Ht	423 12.2 Pt	405 8.2 Ah	427 7.3 Sz
385 12.0 Ht	388 8.2 En	414 12.2 Dw	443 12.7 Pc	406 8.3 Ah	428 7.5 Ah
388 11.8 En	390 7.8 Bl	425 12.8 Dr	443 12.9 Fd	407 8.3 Ah	431 7.6 Ah
390 12.3 Sm	393 8.4 Ch	X Cen	451[12.5 Md	407 8.1 Ch	436 7.6 Mc
390 12.3 Ht	394 8.0 En	*114441*	R Crv	413 8.7 Ah	438 8.1 Me
390 12.1 Bl	396 7.3 Bl	382 13.0 Ht	*121118*	414 8.5 Ah	438 7.9 Fd
394 12.3 En	396 8.4 Ch	390[12.2 Bl	380 11.1 Sl	415 8.7 Ah	439 7.9 Mc
396 12.1 Bl	407 8.2 Ch	391[12.0 En	385 11.5 Kd	415 8.4 Jo	440 8.5 Oy
398 12.3 Ht	420 7.6 Ch	423 13.6 Dr	387 11.3 Sl	417 8.7 Ah	444 8.0 Sz
415 12.3 Dr	422 7.5 Bg	AD Cen	390 11.4 Sl	418 8.4 Wd	446 9.2 Ma
AF Car	423 7.2 Ch	*114858*	395 11.5 Sl	419 8.4 Jo	447 8.4 Mc
101058b	423 6.9 Pt	380 9.1 Ht	397 11.5 Kd	419 8.8 Ah	RS UMa
415 11.8 Dr	443 7.4 Bg	382 9.2 Sm	400 11.8 Sl	421 8.8 Ah	123459
W Vel	RS Hya	385 9.5 Ht	412 12.0 Sl	421 8.8 Pc	393[11.3 Ch
101153	*104628*	390 9.3 Ht	415 12.0 Jo	422 8.9 Al	409 12.8 Bn
380 12.3 Ht	388 9.9 En	390 9.2 Sm	415 12.0 Kd	422 8.7 Wd	422[13.5 B
385 12.3 Ht	390 9.8 Bl	391 9.2 En	419 12.2 Sl	422 8.9 B	423 13.8 Pt
390 12.0 Ht	394 9.8 En	398 9.3 Ht	423 12.1 Pt	422 8.5 Jo	424 14.0 Ma
390 12.0 Sm	396 9.9 Bl	423 9.0 Dr	427 12.5 Sl	423 9.1 Pt	438[12.6 Fd
390 12.0 Bl	W Leo	W Cen	439 12.4 B	424 9.0 Ma	444[13.2 Bn
391 11.8 En	104814	*115058*	443 12.6 Pc	424 8.6 Ch	S UMa
394 12.0 En	387 13.8 Ch	390 12.6 Sm	443 12.5 Fd	425 8.7 Jo	123961
396 11.8 Bl	416 13.8 Ch	390 12.8 Ht	SS Vir	427 9.2 Wd	385 9.8 Ch
398 12.0 Ht	424 14.3 Ma	390 12.9 Bl	*122001*	427 8.9 Ah	407 11.3 Ah
415 11.9 Dr	447[13.8 Ol	391 12.6 En	426 8.8 B	428 9.0 Ah	407 11.1 Ch
U Hya	451[13.4 Eb	396 12.6 Bl	427 8.8 Sz	431 9.1 Ah	414 11.5 Ah
103212	RS Car	398 12.4 Ht	443 8.2 Sz	438 9.5 Fd	415 11.7 Ah
380 5.9 Kd	*110361*	423 9.6 Dr	444 8.1 Bg	440 9.6 Wd	415 11.6 Jo
385 5.9 Kd	380[12.3 Sl	R Com	446 8.8 Md	441 9.4 HS	416 11.8 Ah
385 5.6 Ch	382[12.3 Sm	115919	451 8.9 Md	443 9.7 Wd	417 11.6 Ah
396 5.9 Kd	427[12.3 Sl	394 11.0 Ch	T CVn	444 9.9 Gy	419 11.6 Ah
408 5.6 Ch	S Leo	416 8.5 Ch	122532	445 9.5 Al	419 11.8 Jo
415 5.9 Kd	110506	416 8.7 Jo	394 11.4 Ch	446 9.9 Ma	419 11.8 B
419 6.0 Kd	387 12.5 Ch	419 8.3 Jo	413 10.6 Ke	447 9.8 HS	421 11.5 Pc
421 5.9 Kd	416 13.9 Ch	419 8.5 B	420 10.7 Ch	R Vir	422 11.8 Al
439 4.9 Mc	421 13.3 Ke	422 8.3 Jo	421 11.0 Pc	123307	422 11.8 Jo
447 5.8 Mc	423 13.7 Ke	423 8.2 Pt	421 10.5 Ke	385 8.0 Ch	423 11.5 Pt
RZ Car	423 12.8 Pt	426 8.1 Ws	423 10.4 Ke	403 7.2 Ah	424 12.7 Ma
103270	445 13.4 Ma	426 7.8 BL	423 10.4 Pt	405 7.0 Ah	424 11.5 Ch
385[13.6 Ht	RY Car	427 8.2 Jo	427 10.0 Th	407 7.0 Ah	425 11.9 Jo
394[13.1 En	*111561*	438 7.8 Fd	438 9.9 Fd	408 7.1 Ah	427 11.6 Ah
414 15.0 Dr	382[12.7 Sm	441 8.0 BL	Y Vir	408 6.9 Ch	427 11.6 Sz
414 15.1 Dw	388[13.1 En	443 7.8 BL	*122803*	413 7.2 Ah	443 11.5 Sz
R UMa	390[13.1 Bl	447 8.3 Ol	385 9.4 Ch	414 7.1 Ah	446 12.9 Ma
103769	398[13.1 Ht	SU Vir	416 11.0 Ch	415 7.2 Ah	RU Vir
324 8.6 We	414 14.2 Dr	120012	424 11.8 Ma	416 7.0 Ah	124204
394 11.2 Ch	414 14.2 Dw	416 12.3 Ch	439 13.2 B	417 7.0 Ah	423 9.8 Pt
410 12.0 We	RS Cen	423 12.1 Pt	446 13.6 Ma	418 7.1 Ah	424 10.0 B
413 12.4 Br	*111661*	424 12.1 Ma	U Cen	419 7.1 Ah	443 10.2 Bw
418 12.4 Wd	380 9.9 Ht	426 12.1 B	*122854*	420 7.2 Ah	450 10.1 Bw
419 12.6 B	382 9.5 Sm	427 12.1 Bw	382 12.3 Ht	421 7.2 Ah	U Vir
423 12.5 Pt	385 10.3 Ht	440 12.0 Bw	388 12.5 Ht	421 7.4 Ch	124606
423 13.0 We	388 10.5 En	445 11.8 Ma	390 12.2 Bl	422 7.3 B	394 9.4 Ch

VARIABLE STAR OBSERVATIONS RECEIVED DURING APRIL, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
U VIR	R HYA	T CEN	T APS	U UMI	R CAM
124606	*132422*	*133633*	*134677*	141567	142584
416 11.0 Ch	412 5.6 Ch	410 5.9 Sl	395[12.3 En	427 8.6 Jo	407 10.9 Ch
422 11.4 Al	415 5.7 Ch	415 6.1 Dr	396 13.2 Bl	428 9.2 Ah	413 10.1 Ke
423 11.5 Pt	421 6.2 Ch	419 6.1 Sl	398[13.2 Ht	431 9.0 Ah	421 9.7 Ke
426 11.4 B	423 6.1 Pt	423 6.6 Dr	423 12.8 Dr	444 8.9 Sz	423 11.4 Ke
428 10.7 Me	425 6.3 Ch	426 6.4 Sl	RR VIR	445 9.3 Al	426 9.6 Br
RV VIR	427 5.6 Sl	427 6.7 Me	*135908*	S Boo	R Boo
130212	S VIR	428 6.6 Me	423 11.8 Pt	141954	143227
416[13.8 Ch	*132706*	RT CEN	438 12.5 Fd	394 13.1 Ch	394 9.0 Ch
427[13.1 Bw	387 12.6 Sl	*134236*	440 12.0 Me	408 13.2 Br	403 8.3 Ah
444[13.6 Bg	388 12.3 Ht	382 11.7 Ht	Z Boo	416 13.2 Ch	405 8.2 Ah
450[13.1 Bw	394 12.5 Ch	388 11.4 Ht	140113	RS VIR	406 8.3 Ah
U OCT	398 12.3 Ht	390 11.7 Sm	424 11.0 Ma	142205	407 8.2 Ah
131282	400 12.5 Sl	395 12.0 En	425 11.4 Ch	425 12.4 Ch	408 8.1 Ah
382 9.7 Sm	411 12.2 Sl	396 11.6 Bl	439 10.2 B	439 12.7 B	412 8.0 Ah
382 9.8 Ht	423 12.3 Pt	398 11.4 Ht	446 10.1 Ma	446 12.7 Md	413 8.0 Ah
388 9.3 Ht	423 12.0 Ch	423 10.5 Dr	447 10.2 Ma	451 12.8 Md	414 7.9 Ah
390 9.0 Sm	427 12.1 Sl	R CVN	Z VIR	V Boo	415 7.9 Ah
390 9.2 Bl	438 11.1 Fd	134440	*140512*	142539a	415 7.6 Jo
395 9.0 En	RV CEN	385 9.0 Ch	425[13.2 Ch	394 10.1 Ch	416 7.9 Ch
396 8.5 Bl	*133155*	403 8.4 Ah	RU HYA	403 10.6 Ah	416 7.9 Ah
398 8.8 Ht	380 8.6 Ht	405 8.2 Ah	*140528*	407 10.6 Ah	417 7.8 Ah
415 7.4 Dr	385 8.6 Ht	406 8.2 Ah	388 13.5 Ht	408 10.2 Ah	418 7.8 Ah
423 8.2 Dr	390 8.9 Ht	407 8.2 Ah	396 13.3 Bl	413 10.3 Ah	419 7.7 Ah
V CVN	390 8.5 Bl	408 8.1 Ah	423 13.8 Dr	414 10.2 Ah	419 7.5 Jo
131546	396 8.6 Bl	413 8.0 Ah	R CEN	415 10.4 Ah	420 7.9 Ah
422 7.2 GD	398 9.0 Ht	414 7.9 Ah	*140959*	415 9.8 Jo	421 7.8 Ah
426 7.2 GD	T UMI	415 7.8 Ah	380 6.5 Sl	416 10.7 Ch	422 7.5 Jo
436 7.5 GD	133273	416 7.7 Ah	382 6.7 Ht	417 10.3 Ah	423 7.2 Pt
438 7.6 GD	406 9.7 Ke	416 7.6 Jo	385 6.4 Sm	418 10.5 Sf	424 7.9 Ah
439 7.6 GD	413 8.6 Ke	417 7.6 Ah	387 6.2 Sl	419 9.9 Jo	425 7.5 Jo
440 7.6 GD	416 9.0 Jo	418 7.6 Ah	388 6.6 Ht	419 10.4 Ah	426 7.7 Ah
442 7.6 GD	418 9.0 Wd	419 7.7 Ah	390 6.6 Bl	421 10.3 Ah	427 7.7 Ah
444 7.8 GD	418 8.8 Sf	420 7.6 Ah	393 6.2 En	422 9.9 Jo	428 7.7 Ah
W VIR	419 8.8 Jo	420 7.6 Ch	394 6.1 Sm	422 10.4 Kd	431 7.9 Ah
132002	421 8.8 Ke	421 7.7 Ah	395 6.2 Sl	423 10.1 Pt	432 7.8 Ah
445 10.9 Bg	422 8.5 Al	422 7.6 Kd	396 6.3 Bl	423 10.6 Fd	437 7.6 Me
V VIR	422 8.5 Jo	422 7.4 Jo	398 6.2 Ht	425 9.8 Jo	440 7.5 Me
132202	423 9.1 Ke	423 7.5 Pt	399 6.1 En	426 10.2 Ah	443 7.6 Sz
425[13.2 Ch	426 9.0 Th	426 7.7 Ah	400 6.3 Sl	427 10.1 Ah	V LIB
446 11.8 Ma	427 8.9 Th	427 7.7 Ah	410 6.1 Sl	428 10.1 Ah	*143417*
R HYA	427 8.4 Jo	427 7.3 Jo	415 6.1 Dr	428 10.0 Me	427 11.4 Me
132422	443 9.0 Sf	428 7.7 Ah	418 6.0 Sl	429 10.5 Kd	428 11.2 Me
382 4.5 Ht	T CEN	431 7.9 Ah	423 6.0 Dr	436 9.9 Mc	U Boo
386 4.8 Ch	*133633*	432 7.9 Ah	426 5.7 Sl	438 10.0 Fd	144918
387 4.2 Sl	382 7.1 Ht	441 8.0 BL	U UMI	438 9.2 Me	425 12.3 Ch
388 4.8 Ht	385 7.1 Sm	443 7.9 BL	141567	439 9.8 Mc	427 12.0 Bw
390 4.4 Sl	388 6.7 Ht	444 7.8 Sz	408 9.7 Ah	439 9.4 B	443 11.9 Bw
390 5.1 Sm	390 6.5 Sl	RX CEN	413 9.6 Ah	440 9.3 Me	445 11.5 Al
393 5.0 Ch	390 6.5 Bl	*134536*	414 9.5 Ah	443 9.5 Sf	450 11.6 Bw
395 4.6 Sl	394 6.5 Sm	382 11.9 Ht	415 9.5 Ah	444 9.8 Fd	Y LUP
395 4.8 En	395 6.0 Sl	388 12.1 Ht	416 9.0 Jo	444 9.6 Pc	*145254*
396 5.1 Ch	395 6.4 En	396 12.3 Bl	417 9.4 Ah	445 9.0 Al	390 13.0 Bl
396 5.0 Bl	396 5.9 Kd	398 12.3 Ht	419 9.5 Ah	447 9.5 Mc	396 13.5 Bl
398 4.8 Ht	396 6.2 Bl	423 13.1 Dr	419 8.8 Jo	448 9.5 Mc	423 14.4 Dr
399 5.0 En	398 6.2 Ht	T APS	422 8.7 Jo	R CAM	V APS
400 4.9 Sl	399 6.5 En	*134677*	423 9.8 Pt	142584	*145471*
402 5.2 Kd	400 5.9 Sl	382[13.2 Ht	426 9.2 Ah	393 11.6 Ch	415 9.9 Dr
410 5.1 Sl	402 5.9 Kd	390[12.7 Sm	427 9.3 Ah	406 10.8 Ke	423 9.6 Dr

Variable Star Observations Received During April, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
S Aps	RS Lib	R CrB	R CrB	RR Lib	RU Her
145971	*151822*	154428	154428	*155018*	160625
382 10.1 Ht	388 12.3 Ht	412 6.2 Ah	440 6.0 GD	421 13.6 Ma	421 8.2 Ah
385 9.9 Sm	398 11.5 Ht	413 6.1 Ah	440 6.1 Wd	447 14.3 Ma	421 8.1 Ma
388 10.0 Ht	428 10.2 Me	413 6.2 Ch	441 6.1 Wd	Z CrB	421 8.0 Ch
390 10.1 Bl	RU Lib	414 6.2 Ah	441 6.0 Me	155229	424 8.2 Ah
390 9.9 Sm	*152714*	415 6.1 Ah	441 6.1 Pt	425 11.9 Ch	426 8.1 Ah
395 10.0 En	402 9.2 Ch	415 6.0 Jo	442 6.1 Pt	447 10.3 Md	427 8.1 Ah
396 10.1 Bl	425 10.1 Ch	416 6.1 Ah	442 6.0 Oy	451 10.5 Md	431 8.2 Ah
398 10.1 Ht	438 10.6 Pt	416 6.1 Ch	442 6.1 Pc	RZ Sco	438 7.8 Pt
415 9.8 Dr	R Nor	417 6.1 Ah	443 6.0 Sz	*155823*	443 8.2 Pc
423 9.8 Dr	*152849*	418 6.1 Ah	443 6.1 Pc	388 12.2 Ht	443 8.0 Fd
RT Lib	382 7.5 Ht	418 6.3 Wd	443 6.0 Mg	398 11.2 Ht	444 8.4 HS
150018	388 7.5 Ht	419 6.2 Wd	443 6.1 Wd	438 8.5 Pt	445 7.7 Ma
427 10.6 Me	396 7.9 Bl	419 6.0 Jo	443 6.1 Pt	Z Sco	450 8.3 HS
428 10.7 Me	396 7.9 En	419 6.1 Ah	444 6.2 Pt	*160021*	R Sco
438 11.4 Pt	398 8.2 Ht	420 6.2 Ah	444 6.1 Pc	388 12.0 Ht	*161122a*
440 11.3 Me	423 8.8 Dr	421 6.2 Ah	444 6.5 HS	398[12.0 Ht	388[12.6 Ht
T Lib	W Lib	421 6.0 Pc	444 5.9 Gy	R Her	398[12.6 Ht
150519	*153215*	421 6.0 Me	444 6.1 Fd	160118	S Sco
402 12.6 Ch	402[12.1 Ch	422 6.0 GD	445 6.5 Al	438 13.5 Pt	*161122b*
425[12.4 Ch	425[13.0 Ch	422 6.2 Wd	447 6.0 Oy	443 13.0 Fd	398[12.6 Ht
Y Lib	S UMi	422 6.0 Jo	447 6.0 Mc	443 13.0 Pc	440 13.8 Pt
150605	153378	422 6.1 Pt	447 6.4 HS	RR Her	W CrB
427 12.0 Me	394 11.8 Ch	422 6.1 Kd	450 6.3 HS	160150	161138
428 11.8 Me	415 10.8 Jo	423 6.1 Pt	450 5.9 Oy	427 8.6 Me	440 13.8 Pt
438 11.8 Pt	418 11.2 Sf	423 6.1 Pc	454 5.8 Oy	441 8.6 Me	444[12.2 Pc
440 12.3 Me	419 10.8 Jo	423 6.0 Tf	458 6.0 Oy	U Ser	444[12.5 Fd
U CrB	421 11.6 Ch	423 6.2 Fd	460 5.8 Oy	160210	451[11.8 Md
151432	422 10.7 Jo	423 6.1 Ch	X CrB	421 9.9 Ma	452[12.3 Md
415 7.8 Jo	422 11.5 Pt	424 6.1 Ah	154536	438 11.0 Pt	W Oph
419 7.7 Jo	427 10.6 Jo	424 6.3 Wd	424 13.1 Ma	440 11.3 Me	*161607*
422 7.6 Jo	437 10.1 Gy	426 6.2 Ah	425 12.0 Ch	443 11.2 Pc	440 10.0 Pt
S Lib	443 10.5 Sf	426 5.9 Me	438 13.6 Pt	443 11.2 Fd	V Oph
151520	444 10.2 Gy	426 6.0 GD	447 13.5 Ma	446 11.6 Al	*162112*
402 10.8 Ch	445 10.5 Al	427 6.1 Ah	R Ser	447 10.9 Ma	393 9.0 Ch
425 9.6 Ch	U Nor	427 6.0 Me	154615	SX Her	428 9.9 Me
428 9.8 Me	*153454*	427 6.1 Ch	393 8.8 Ch	160325	440 9.0 Pt
S Ser	423 10.0 Dr	427 6.1 Wd	421 9.5 Ch	423 8.0 Pt	U Her
151714	T Nor	428 6.0 Me	438 10.1 Pt	436 8.0 Pt	162119
424 13.2 Ma	*153654*	431 6.2 Ah	447 11.0 Md	437 8.0 Pt	393 8.9 Ch
425 13.0 Ch	382 7.3 Ht	432 6.1 Ah	V CrB	438 8.1 Pt	403 9.3 Ah
447 13.2 Ma	388 7.4 Ht	432 6.0 Me	154639	439 8.1 Pt	406 9.3 Ah
S CrB	396 7.5 En	432 6.0 Jo	425 11.0 Ch	440 8.0 Pt	408 9.3 Ah
151731	398 7.4 Ht	436 6.1 Pt	438 9.3 Pt	441 8.1 Pt	413 9.5 Ah
393 10.5 Ch	423 8.1 Dr	436 6.1 Pc	439 9.2 Mc	442 8.0 Pt	414 9.7 Ah
415 10.7 Jo	R CrB	436 6.1 Me	443 11.3 Bw	443 8.2 Pt	415 9.7 Ah
419 11.3 Jo	154428	436 6.0 Me	447 9.4 Mc	444 8.0 Pt	415 9.0 Jo
421 11.8 Ch	377 6.1 Ch	437 6.1 Pt	447 11.2 Md	RU Her	418 9.8 Ah
421 11.1 Pc	392 6.2 Ch	438 6.1 Pt	450 11.2 Bw	160625a	419 9.8 Ah
422 12.0 Kd	395 6.2 Ch	438 6.1 Fd	451 11.3 Md	393 10.9 Ch	419 9.1 Jo
422 11.3 Jo	396 6.2 Kd	438 5.9 Me	R Lib	403 10.0 Ah	420 9.6 Ah
423 10.7 Fd	402 6.1 Kd	439 6.0 Me	*154715*	408 9.7 Ah	421 9.7 Ch
426 10.5 Th	402 6.2 Ch	439 6.0 Mg	425 11.1 Ch	413 9.2 Ah	422 9.7 Jo
438 12.0 Fd	403 6.2 Ah	439 6.1 Mc	438 11.2 Pt	414 8.8 Ah	427 10.0 Ah
438 11.8 Pt	405 6.0 Ah	439 6.0 GD	R Lup	415 8.6 Ah	440 10.2 Pt
444 12.0 Fd	405 6.1 Kd	439 6.1 Pt	*154736*	416 8.6 Ah	443 10.3 Pc
444 12.1 Pc	406 6.1 Ah	440 6.1 Pt	423 11.3 Dr	417 8.7 Ah	443 10.5 Fd
	407 6.0 Ah	440 6.0 Oy		418 8.4 Ah	444 10.5 Gy
	408 6.1 Ah	440 6.0 Me		419 8.3 Ah	

VARIABLE STAR OBSERVATIONS RECEIVED DURING APRIL, 1931.

J.D.	Est.	Obs.
SS HER		
162807		
440	9.6	Pt
444	9.3	Fd
444	9.7	Pc
T OPH		
162815		
440	9.5	Pt
W HER		
163137		
393	11.7	Ch
421	13.3	Ma
440	13.5	Pt
444	13.7	Pc
444	13.5	Fd
445	13.4	Ma
R UMI		
163172		
415	9.3	Jo
419	9.3	Jo
422	9.1	Jo
427	9.0	Jo
R DRA		
163266		
393	10.7	Ch
415	10.9	Jo
418	11.6	Wd
419	11.3	Jo
421	11.4	Ch
421	11.4	Ma
422	11.7	Jo
423	11.5	Fd
424	11.4	Wd
425	11.9	Jo
427	11.6	Wd
437	11.8	Gy 2
438	11.6	Fd
440	12.0	Pt
441	11.7	Wd
443	11.8	Wd
444	11.6	Pc
444	11.7	Fd
447	12.1	Ma
RR OPH		
164319		
440	13.0	Pt
S HER		
164715		
393	10.0	Ch
403	9.6	Ah
405	9.6	Ah
408	9.6	Ah
413	9.5	Ah
414	9.5	Ah
415	9.5	Ah
415	9.9	Jo
418	9.4	Ah
S HER		
164715		
419	9.5	Ah
419	9.9	Jo
420	9.4	Ah
421	9.5	Ah
427	9.3	Ah
431	9.4	Ah
440	9.1	Pt
444	9.0	Fd
444	9.1	Pc
RS SCO		
164844		
388	11.5	Ht
398	11.0	Ht
423	9.5	Dr
RR SCO		
165030a		
387	7.3	Sl
388	7.4	Ht
398	7.2	Ht
423	5.7	Dr
400	6.8	Sl
420	5.8	Sl
427	5.4	Sl
RV HER		
165631		
440	10.8	Pt
443	10.2	Bw
452	10.1	Md
SS OPH		
165202		
440	13.2	Pt
RT SCO		
165636		
423	[14.5	Dr
R OPH		
170215		
393	6.8	Ch
427	7.0	Me
440	7.7	Pt
444	8.2	Gy
RT HER		
170627		
444	14.0	Pc
RW SCO		
170833		
423	[13.5	Dr
α HER		
171114		
439	2.9	Mc
447	3.2	Mc
Z OPH		
171401		
440	10.5	Pt
RS HER		
171723		
440	10.2	Pt
443	10.2	Bw
S OCT		
172486		
388	[13.0	Ht
396	12.9	Bl
423	12.3	Dr
RU OPH		
172809		
421	13.7	Ma
440	12.6	Pt
444	12.7	Gy
447	12.4	Ma
RU SCO		
173543		
423	13.7	Dr
TV SCO		
173643		
423	11.2	Dr
SX SCO		
174035		
423	7.7	Dr
SV SCO		
174135		
423	[13.5	Dr
W PAV		
174162		
388	[13.0	Ht
396	[12.3	Bl
423	[13.3	Dr
RS OPH		
174406		
440	11.1	Pt
U ARA		
174551		
388	10.8	Ht
398	11.9	Ht
423	13.2	Dr
RT OPH		
175111		
440	10.2	Pt
T DRA		
175458a		
427	12.4	Ch
UY DRA		
175458b		
427	11.1	Ch
RY HER		
175519		
393	9.8	Ch
427	10.5	Ch
440	11.8	Pt
444	12.0	Pc
444	11.9	Fd
447	11.9	Ma
V DRA		
175654		
427	[13.1	Ch
440	13.4	Pt
R PAV		
180363		
388	8.9	Ht
R PAV		
180363		
398	9.3	Ht
423	10.4	Dr
T HER		
180531		
393	11.0	Ch
427	12.9	Ch
440	12.5	Pt
443	11.5	Fd
443	11.5	Pc
W DRA		
180565		
440	11.7	Pt
444	11.9	Fd
444	11.7	Pc
X DRA		
180666		
440	10.8	Pt
444	[12.5	Pc
RY OPH		
181103		
387	7.7	Sl
400	7.5	Sl
420	9.0	Sl
427	9.4	Sl
440	11.5	Pt
W LYR		
181136		
440	12.0	Pt
RV SGR		
182133		
415	8.1	Dr
423	7.5	Dr
T SER		
182306		
398	[12.2	Ch
SV DRA		
183149		
447	[13.9	Ma
X OPH		
183308		
393	8.5	Ch
415	7.4	Ch
428	7.5	Me
446	7.4	Pt
RY LYR		
184134		
395	12.8	Ch
426	10.5	Ch
446	10.3	Pt
R SCT		
184205		
387	5.9	Sl
393	5.8	Ch
400	5.6	Sl
415	6.9	Ch
420	6.1	Sl
424	6.5	Ma
424	6.4	Bg
R SCT		
184205		
426	6.1	Me
426	6.9	Ch
427	6.3	Sl
427	6.2	Me
440	5.8	Me
440	5.5	Pt
443	5.9	Pt
443	5.4	Ma
444	5.4	Ma
444	5.5	Pc
444	5.6	Fd
447	5.2	Ma
NOV AQL		
184300		
426	11.0	Ch
440	11.7	Pt
447	10.8	Ma
RX LYR		
185032		
395	[13.0	Ch
426	[13.0	Ch
R LYR		
185243		
426	4.4	Mc
447	4.2	Mc
S CRA		
185437a		
387	12.1	Sl
400	11.9	Sl
420	11.5	Sl
427	11.7	Sl
ST SGR		
185512a		
426	[12.6	Ch
R CRA		
185537a		
387	12.2	Sl
400	13.5	Sl
427	13.5	Sl
T CRA		
185537b		
387	13.3	Sl
400	12.9	Sl
420	13.3	Sl
427	13.3	Sl
Z LYR		
185634		
395	13.0	Ch
426	12.9	Ch
RT LYR		
185737		
426	13.4	Ch
444	13.0	Fd
444	12.6	Pc
R AQL		
190108		
426	[13.0	Ch
426	11.0	Ch
440	11.7	Pt
447	10.8	Ma
RX LYR		
185032		
395	[13.0	Ch
426	[13.0	Ch
R LYR		
185243		
426	4.4	Mc
447	4.2	Mc
S CRA		
185437a		
387	12.1	Sl
400	11.9	Sl
420	11.5	Sl
427	11.7	Sl
ST SGR		
185512a		
426	[12.6	Ch
R CRA		
185537a		
387	12.2	Sl
400	13.5	Sl
427	13.5	Sl
T CRA		
185537b		
387	13.3	Sl
400	12.9	Sl
420	13.3	Sl
427	13.3	Sl
Z LYR		
185634		
395	13.0	Ch
426	12.9	Ch
RT LYR		
185737		
426	13.4	Ch
444	13.0	Fd
444	12.6	Pc
R AQL		
190108		
393	8.1	Ch
405	8.3	Ah
R AQL		
190108		
415	8.6	Ch
416	9.4	Ah
419	9.5	Ah
424	9.6	Ah
431	10.0	Ah
443	9.8	Pt
V LYR		
190529a		
426	[13.3	Ch
RX SGR		
190818		
400	11.2	Ch
415	11.0	Ch
443	9.9	Pt
447	9.8	Ma
RW SGR		
190819a		
400	10.8	Ch
415	9.9	Ch
443	9.6	Pt
447	9.3	Ma
TY AQL		
190907		
443	10.2	Pt
S LYR		
190925		
396	13.4	Ch
426	14.0	Ch
X LYR		
190926		
440	8.8	Pt
RS LYR		
190933a		
395	10.7	Ch
426	11.5	Ch
443	11.9	Pt
RU LYR		
190941		
395	12.0	Ch
426	13.0	Ch
443	12.8	Pc
U DRA		
190967		
443	13.5	Pt
W AQL		
191007		
400	9.8	Ch
426	10.4	Ch
443	11.2	Pt
T SGR		
191017		
400	8.8	Ch
415	9.4	Ch
443	10.5	Pt
R SGR		
191019		
400	8.2	Ch
415	**7.0**	**Ch**

VARIABLE STAR OBSERVATIONS RECEIVED DURING APRIL, 1931.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
R SGR	RT AQL	S CYG	ST CYG	T CEP	R IND
191019	193311	200357	202954	210868	*222867*
426 7.0 Me	396[12.3 Ch	427 13.1 Ch	444 10.8 Gy	420 8.4 Ah	385 11.6 Ht
427 7.1 Me	425[13.2 Ch	440 12.5 Pt	V VUL	421 8.3 Ah	389 11.4 Bl
428 6.9 Me	R CYG	444[12.9 Pc	203226	423 8.2 Fd	390 11.4 Ht
443 7.1 Pt	193449	S AQL	440 8.9 Pt	424 8.7 Ah	395 10.6 Bl
RY SGR	415[11.4 Ch	200715a	Y DEL	425 8.0 Jo	T TUC
191033	440[13.5 Pt	427 9.5 Me	203611	427 8.3 Ah	*223462*
414 13.5 Dw	444[12.8 Pc	427 9.4 Ch	443 13.9 Ma	427 8.2 Wd	380 9.3 Ht
414 13.3 Dr	RV AQL	440 9.6 Pt	S DEL	428 8.6 Ah	R LAC
423 13.1 Dr	193509	RW AQL	203816	431 8.6 Ah	223841
443[12.0 Pt	443 9.4 Pt	200715b	443 9.3 Pt	437 8.8 Gy	378[13.4 Ch
TY SGR	T PAV	440 9.2 Pt	V CYG	438 8.4 Fd	RW PEG
191124	*193972*	RU AQL	203847	443 8.5 Pt	225914
415 10.3 Dr	388[13.2 Ht	200812	443 13.0 Pt	RR AQR	444 13.0 Ma
423 10.3 Dr	395[13.2 Bl	443[13.0 Ma	443 12.8 Ma	*210903*	V CAS
S SGR	423 11.8 Dr	Z AQL	T DEL	443 10.4 Pt	230759
191319a	RT CYG	*200906*	204016	Y PAV	393 11.6 Ch
400 11.2 Ch	194048	443 12.1 Pt	443 12.5 Pt	211570	443 8.6 Pt
415 10.2 Ch	393 9.5 Ch	R SGE	V AQR	380 5.9 Ht	RY CEP
427 10.6 Me	403 10.0 Ah	200916	204102	385 5.8 Ht	231878
428 10.5 Me	414 11.3 Ah	427 8.6 Me	443 8.0 Pt	390 5.4 Ht	386[11.0 Ch
SW SGR	415 11.2 Ah	RS CYG	V DEL	X PEG	V PHE
191331	415 11.0 Ch	200938	204318	211614	*232746*
423 13.3 Dr	416 11.3 Ah	395 7.1 Ch	443[13.9 Ma	421 11.1 Ma	379 10.8 En
TZ CYG	417 11.1 Ah	400 7.2 Ch	T AQR	443 12.8 Ma	380 11.0 Ht
191350	418 11.2 Ah	415 7.2 Ch	*204405*	443 13.0 Pt	ST AND
440 10.8 Pt	419 11.2 Ah	426 7.3 Me	443 9.0 Pt	W CYG	233335
U LYR	420 11.1 Ah	427 7.2 Me	RZ CYG	213244	443 9.1 Pt
191637	440 11.8 Pt	427 7.2 Ch	204846	379 6.4 Kd	R AQR
440 10.5 Pt	444 9.4 Gy	440 7.2 Pt	443 12.0 Pt	S CEP	*233815*
444 11.1 Fd	444 12.1 Fd	R DEL	R VUL	213678	379 9.1 Ch
444 11.0 Pc	444 12.2 Pc	201008	205923a	332 10.7 Wr	RR CAS
AF CYG	TU CYG	440 10.9 Pt	443 9.7 Pt	443 11.8 Pt	235053
192745	194348	RT CAP	X CEP	RU CYG	394 11.2 Bn
403 6.5 Ah	398[11.2 Ch	*201121*	210382	213753	409 11.1 Bn
405 6.5 Ah	440 13.0 Pt	440 6.8 Pt	413[13.9 Br	403 8.3 Ah	415 10.8 Bn
406 6.6 Ah	444[12.4 Fd	SX CYG	426[13.9 Br	405 8.4 Ah	443 11.0 Bn
407 6.7 Ah	χ CYG	201130	R EQU	407 8.3 Ah	449 11.1 Bn
408 6.7 Ah	194632	440 9.9 Pt	210812	414 8.1 Ah	R TUC
413 6.8 Ah	427[13.0 Ch	WX CYG	443[13.9 Ma	415 8.1 Ah	*235265*
414 6.9 Ah	443 13.5 Pt	201437b	T CEP	417 8.1 Ah	379[12.9 En
415 6.9 Ah	444[10.1 Gy	440 10.6 Pt	210868	418 8.0 Ah	382[12.9 Sm
416 6.7 Ah	S PAV	U CYG	400 7.6 Ch	419 8.0 Ah	385[13.3 Ht
417 6.9 Ah	*194659*	201647	403 7.6 Ah	420 8.0 Ah	398[13.0 Ht
418 7.0 Ah	423 8.4 Dr	398 8.1 Ch	405 7.7 Ah	421 7.9 Ah	R CAS
419 6.9 Ah	RR SGR	427 8.1 Me	406 7.7 Ah	424 7.8 Ah	235350
420 7.0 Ah	*194929*	427 8.1 Ch	407 7.9 Ah	427 7.9 Ah	375 5.8 Ch
421 7.1 Ah	423 6.3 Dr	440 8.6 Pt	408 7.9 Ah	431 8.0 Ah	403 5.7 Ah
424 7.2 Ah	RR AQL	443 8.1 Fd	413 7.9 Ah	440 7.7 Pt	405 5.9 Ah
427 7.3 Ah	*195202*	443 8.3 Pc	414 7.9 Ah	RV CYG	406 6.0 Ah
431 7.4 Ah	443 12.0 Pt	RW CYG	415 8.0 Ah	213937	407 6.0 Ah
432 7.3 Ah	NOV CYG	202539	415 8.0 Ch	440 6.7 Pt	407 5.8 Ch
TY CYG	195553	427 8.2 Me	415 7.8 Jo	R GRU	408 6.0 Ah
192928	427[13.1 Ch	Z DEL	416 8.2 Ah	*214247*	412 6.2 Ah
396 12.0 Ch	440[12.2 Pt	202817	417 8.2 Ah	388 9.1 Bl	413 6.2 Ah
426 10.4 Ch	443[12.2 Pt	443 11.8 Ma	418 8.1 Ah	395 9.5 Bl	414 6.2 Ah
440 10.0 Pt	Z CYG	ST CYG	418 6.4 Wd	R IND	415 6.1 Ah
	195849	202954	419 7.8 Jo	*222867*	415 6.5 Jo
	427 11.5 Ch	440 10.8 Pt	419 8.3 Ah	380 12.2 Ht	416 6.3 Ah

RAPIDLY VARYING IRREGULAR VARIABLES.

005840 RX ANDROMEDAE—
6380.1 12.8 Ch 6423.7[11.3 Pt

060547 SS AURIGAE—
6378.1[13.9 Ch 6430.2[11.2 Ch
6387.2[13.9 Ch 6434.7[11.0 Pt
6393.2 11.6 Ch 6436.6[12.6 Pc
6396.2 13.5 Ch 6437.7[12.0 Pt
6412.6[14.0 B 6438.6[14.0 B
6413.7[14.5 Br 6439.7[12.6 Mg
6414.7 14.7 Br 6440.8[12.5 Me
6419.6[14.0 B 6441.7[12.4 Pt
6421.6[12.6 Pc 6442.7[12.6 Pt
6423.4[12.7 Md 6443.6[12.5 Fd
6424.6[13.2 Al 6444.8[12.6 Pt
6426.7[13.9 Br 6445.6[13.9 Bg
6427.5[13.2 Bw 6450.5[13.8 Bw

074922 U GEMINORUM—
6378.1 13.8 Ch 6435.7 9.2 Br
6380.0 13.7 Sl 6436.2 **9.1 Ch**
6386.0 13.7 Sl 6436.6 **9.2 Bw**
6388.1 13.7 Ch 6436.7 9.1 Pt
6390.0 13.7 Sl 6436.7 9.1 Pc
6395.0 13.5 Sl 6436.7 9.0 Me
6395.2 13.8 Ch 6437.7 9.2 Me
6410.0 13.7 Sl 6437.7 8.9 Pt
6412.0 13.7 Sl 6438.7 9.1 Me
6412.7 13.7 B 6438.6 8.9 B
6413.6 13.7 Br 6438.7 9.0 Pt
6414.6 13.8 Br 6439.6 8.9 B
6417.7 13.9 Br 6439.7 9.2 Pt
6418.6 13.9 Bg 6439.7 9.3 Me
6419.2 13.8 Ch 6440.7 **9.4 Me**
6419.6 14.0 B 6440.7 9.4 Bw
6419.6 13.9 Bg 6441.7 9.6 Me
6419.9 13.5 Sl 6441.7 9.1 Bg
6421.7 13.2 Ke 6441.7 9.5 Pt
6422.6 13.6 Bg 6442.7 9.6 Pt
6423.7 13.6 Ke 6442.7 9.6 Me
6424.0 13.6 Sl 6442.7 **9.7 Pc**
6424.2 13.8 Ch 6443.6 9.2 Bg
6424.7 13.4 Ma 6443.6 9.4 Fd
6426.7 13.6 Br 6443.7 9.7 Pc
6434.7 10.6 Br 6443.8 9.6 Pt

074922 U GEMINORUM—
6444.6 9.4 Bg 6445.6 9.6 Bg
6444.6 9.5 Fd 6445.7 9.2 Ma
6444.6 9.8 Pc 6447.6 10.1 Bw
6444.8 9.6 Pt 6447.7 9.5 Ma

081473 Z CAMELOPARDALIS—
6393.1 11.3 Ch 6442.7 11.6 Me
6407.1 11.0 Ch 6443.3 11.3 Md
6413.7 12.8 Br 6444.6 11.8 Bg
6414.6 12.6 Br 6445.6 11.8 Bg
6426.7 11.3 Br 6446.5 11.2 Md
6432.7 11.6 Br 6450.4 11.7 Md
6434.7 11.7 Br 6451.3 11.9 Md
6440.8 11.8 Me 6452.3 **11.7 Md**
6441.7 11.7 Me

094512 X LEONIS—
6413.7[14.2 Br 6426.7[13.9 Br
6418.6 12.1 Bg 6438.6 12.9 B
6419.6 12.1 Bg 6441.7[13.3 Bg
6422.6 12.1 Bg 6444.6[13.3 Bg
6423.7[13.3 Pt 6445.6[13.3 Bg
6424.6 12.7 B 6447.6 12.6 Ol

202946 SZ CYGNI—
6436.7 9.6 Pt 6443.8 9.0 Pt
6440.9 9.6 Pt 6444.8 9.6 Pt

213843 SS CYGNI—
6380.0 11.9 Ch 6421.5 11.8 Ah
6396.5 11.9 Ch 6421.9 11.9 Ma
6400.5 8.2 Ch 6424.6 11.8 Ah
6403.3 8.7 Ah 6424.9 11.9 Ma
6405.3 8.7 Ah 6426.5 **11.8 Ch**
6405.7 8.7 Ah 6427.5 11.8 Ah
6406.3 8.8 Ah 6440.9 9.6 Pt
6407.3 8.8 Ah 6440.9 9.4 Me
6413.5 10.6 Ah 6443.8 10.2 Ma
6414.5 10.9 Ah 6443.8 10.0 Fd
6415.5 11.0 Ah 6443.8 10.2 Pc
6416.6 11.4 Ah 6443.9 10.2 Pt
6417.5 **11.5 Ah** 6444.8 9.6 Pc
6418.5 11.5 Ah 6444.8 10.5 Fd
6419.5 11.6 Ah 6444.9 **10.3 Ma**
6420.5 11.8 Ah 6447.8 10.6 Ma

SUMMARY OF OBSERVATIONS FOR APRIL, 1931.

Observer	Initial	Vars.	Observations	Observer	Initial	Vars.	Observations
Ahnert	Ah	33	396	Ebert	Eb	15	16
Allen	Al	21	26	Ensor	En	54	98
Baldwin	Bl	59	99	Ford	Fd	49	66
Bigelow	Bw	16	33	Godfrey Club	GD	4	15
Boutell	BL	12	34	Gregory	Gy	14	15
Bouton	B	55	72	Haas	HS	6	15
Brocchi	Br	18	36	Houghton	Ht	66	169
Brown	Bn	4	17	Jones	Jo	39	136
Bunting	Bg	23	45	Konda	Kd	15	29
Buckstaff	Bc	1	1	Kline	Ke	11	34
Chandra	Ch	179	392	Marsh	Ma	47	72
Cole	Co	13	15	McLeod	Mc	17	55
Dartayet	Dr	78	122	McPherson	Mp	6	7
Dawson	Dw	15	18	Meek	Me	49	101

VARIABLE STAR OBSERVATIONS RECEIVED DURING APRIL, 1931.

Observer	Initial	Vars.	Observations	Observer	Initial	Vars.	Observations
Millard	Md	16	26	Taffara	Tf	3	5
Monnig	Mg	12	17	Theile	Th	8	18
O'Byrne	Oy	6	24	Wares	Ws	5	7
Olivier	Ol	9	9	Weatherbee	We	2	9
Peltier	Pt	182	239	Webb	Wd	15	52
Proctor	Pc	51	74	Winne	Wg	9	9
Shinkfield	Sl	23	121	Wright	Wr	2	4
Shultz	Sz	10	15				
Smith, F. W.	Sf	15	39	Totals	45	350	2870
Smith, W. H.	Sm	41	68				

maximum by Mr. Brocchi on April 2. This was only a few days before Mr. Brocchi had to be rushed to the hospital for an appendicitis operation. Other observers secured a remarkably fine series of observations through maximum and down to minimum. For the first time in many months we lacked the usual quota of observations from Signor Lacchini.

This is the largest single month's report submitted in several years not only in number of observations secured but in number of observers represented.

LEON CAMPBELL, Recording Secretary.

May 14, 1931.

METEOR NOTES

By CHARLES P. OLIVIER.

During the past several years the writer has received many specimens of what were supposed to be meteorites but were not. At last, thanks to the kindness of one of our active members in Australia, Mr. R. C. Shinkfield of the Weather Bureau at Adelaide, S. A., a fragment of the meteorite of November 25, 1930, has been received. In an accompanying letter, Mr. Shinkfield outlines briefly the history of the meteorite, sends a map showing its approximate path over South Australia, and a newspaper print showing the collected fragments. From the map, the direction of motion was towards azimuth 325°—not far from S.E. The fragment sent here weighs several ounces and is of dark gray stone, showing evidence of bad shattering, there being several small cracks. Minute quantities of metals can be easily recognized by using a magnifying glass. At a guess, however, over 95 per cent of the mass is stony. Mr. Shinkfield's account will now be given in full:

THE KAROONDA (SOUTH AUSTRALIA) METEORITE OF NOVEMBER 25, 1930.

A very brilliant meteor fell near Karoonda at 10:53 P.M. on November 25, 1930. Its size and brightness led many observers at Adelaide to believe that it had actually fallen near the city, but after considering reports received from other places in South Australia, it appeared certain that the meteorite had fallen near Karoonda, about 75 miles east-south-east of Adelaide.

In response to requests, the Government Astronomer (Mr. G. F. Dodwell) received over 130 reports from different parts of the State, and as to the general appearance of the meteor, most observers agree. When it first became luminous, the meteor appeared like a bright red star which rapidly became brilliant with a tail of 5° to 10° in length, and as it fell nearer the earth there was a flash of bluish light which lighted up the surroundings of Adelaide as day, and was seen

at Port Lincoln, Broken Hill, and Mount Gambier which are 230, 240, and 200 miles respectively from Karoonda. At Mount Gambier, the flash was bright enough to throw shadows. One observer states that he saw sparks being shot forward as the meteor faded. The meteor ceased to be luminous before reaching the ground.

It seems remarkable that several people, mostly in Adelaide, reported having heard a hissing, sizzling or swishing sound as the meteor passed through the sky. One observer, whom I know and questioned, was sure that he heard the swishing noise before he saw the meteor. It seems strange that some should have heard the noise and others in the same locality should not. However, I will leave the matter at that.

Messrs. Honeyman and Millard, of Karoonda, who were near the spot where the meteorite fell, give the following description: ". . . the disappearance of the meteor was followed by a loud detonation as though a heavy charge of explosive had been let off underground. This caused a distinct vibration of buildings and telephone wires nearby. This was followed by a loud crackling and rending sound in the sky from the direction (NW) in which the meteor disappeared, and then by a low rumbling of thunder which gradually died away."

From this report it was evident that the meteorite had landed very near Karoonda, and on December 6, a party from the Adelaide University and the Adelaide Observatory left for Karoonda. Two days were spent in making enquiries from observers, and early on the third morning Professor Kerr Grant, of the Adelaide University, found the meteorite in a fallow field 2¼ miles east of Karoonda. The crater it made was 18 inches in diameter and about the same in depth, with a surrounding ridge of soil 3 feet 6 inches across. The meteorite had broken into many fragments on striking the ground. The pieces varied from an ounce to 7 pounds in weight, and when the whole was collected, the total weight was 92 pounds. It is of a dark grey colour, but as the chemical analysis has not yet been completed, very little can be said about its composition.

The detonation was heard at least 40 miles from where the meteor fell, the general description being a rumbling like thunder which, as an observer at Wanbi stated, lasted 40 seconds.

Owing to the lack of reliable data, a beginning point cannot be fixed with any degree of certainty. It appears that the meteorite descended at an angle of about 70 degrees with the horizontal, and the duration of the flight about 6 seconds.

An interesting account has come from Mr. Noah W. McLeod, A.A.V.S.O., Christine, North Dakota, of a meteor shower of brief duration seen by him while observing variables. On April 15, which was perfectly clear, from 10:00 to 10:35, he saw from 28 to 30 meteors from a radiant which he determined from 10 plotted paths to be at $\alpha = 234°$, $\delta = +37°$. The meteors were reddish in color, and were rather faint, the 6 brightest being between magnitude 2 and 3.

As more persons observe, accounts of such showers become increasingly numerous. It proves that the earth frequently meets small, isolated groups of meteors, the groups having such small cross sections that they can be seen from only a very restricted territory.

We welcome as new members:

M. Geddes, Otunui Rural Delivery, Taumarunui, New Zealand.
Chas. F. Kelley, 140 Nassau Street, New York City.
Prof. C. C. Wylie, Dept. of Astronomy, Univ. of Iowa, Iowa City, Iowa.

GORDON W. RIDLEY, ALAMEDA, CALIFORNIA.

1931		Began	Ended	Total	Meteors	F	Rate	Cor.Rate
April	14	13:11	14:11	60	9	1.0	9.0	9.0
	15	12:57	13:57	60	7	1.0	7.0	7.0
	16	12:55	13:55	60	9	1.0	9.0	9.0
	17	12:55	13:55	60	6	1.0	6.0	6.0

B. C. Darling, Lansing, Michigan.

1931		Began	Ended	Total	Meteors	F	Rate	Cor.Rate	Remarks
Jan.	1	9:18	14:34	131	2	0.3	0.9		Moon
	9	12:13	13:13	60	1	1.0	1.0	1.0	
Feb.					6				4 nights, short watches
Mar.	22	12:12	12:48	36	0	0.8	0.0	0.0	
April	4	12:45	13:35	50	1	0.4	0.8		Moon
	6	8:34	9:15	41	2	0.8	2.9	3.6	
	11	11:52	12:32	40	0	0.8	0.0	0.0	
	17	10:22	11:49	87	11	1.0	7.6	7.6	
		14:20	15:05	45	2	1.0	2.7	2.7	3 more later
	30	8:20	9:20	60	0	0.4	0.0	0.0	Moon
May	2	14:52	15:34	42	2	0.4	2.9		Moon
					4				Casuals

Dr. J. M. MacQueen, Birmingham, Alabama.

1931		Began	Ended	Total	Meteors	F	Rate	Cor.Rate
Mar.	16	10:30	11:30	60	1	1.0	1.0	1.0
April	9	8:30	10:30	120	7	1.0	7.0	7.0
	20	8:30	10:30	120	2	0.5	1.0	2.0

Clarence Abernathy, Clearwater, Florida.

1931		Began	Ended	Total	Meteors	F	Rate	Cor.Rate
April	21	9:20	9:50	30	7	0.7	14.0	20.0
	22	8:25	9:10	45	6	1.0	8.0	8.0

Franklin W. Smith, Glenolden, Pennsylvania.

1931		Began	Ended	Total	Meteors	F	Rate	Cor.Rate
Mar.	23	15:00	16:44	104	6	1.0	3.5	3.5
	26	15:30	16:40	70	2	1.0	1.7	1.7
April	8	8:55	9:45	50	0	1.0	0.0	0.0
	11	14:10	15:40	90	3	1.0	2.0	2.0
	14	13:25	14:30	65	5	1.0	4.6	4.6
	19	9:00	10:00	60	0	1.0	0.0	0.0
	20	9:30	11:00	90	4	1.0	2.7	2.7
	21	9:10	10:30	60	0	1.0	0.0	0.0

M. Geddes, Taumarunui, New Zealand.

1931		Began	Ended	Total	Meteors	F	Rate	Cor.Rate	Remarks
Feb.	3	20:16	21:16	60	1	0.4	1.0		Moon
	5	20:26	21:37	71	3	0.5	2.5	5.0	Moon
	8	19:57	22:02	125	13	1.0	6.3	6.3	
	9	20:18	22:13	115	9	0.8	4.7	5.9	
	11	20:28	21:23	55	6	1.0	6.6	6.6	
	14	19:54	21:36	102	4	1.0	2.4	2.4	
	15	20:28	22:34	126	15	0.7	7.1	10.1	
	16	20:47	21:59	72	6	1.0	5.0	5.0	
	18	20:13	22:36	143	19	1.0	8.0	8.0	
	26	20:05	21:05	60	3	0.6	3.0	5.0	

Flower Observatory, Upper Darby, Pennsylvania, May 23, 1931.

Meteorite or Petrified Lightning

In the May issue of Popular Astronomy reference was made to the press report of a meteor cutting a power line near Herman, Nebraska, in the early morning hours of April 15, 1931. The story was that the flames had leaped forty feet high and that the town was without lights for four or five hours until the break in the line was repaired. The first report was followed by a second, to the effect that Mr. Christensen had refused an offer of $500 for the "meteor," and that the owner of the land, Mrs. Carrie Voss of Omaha, was investigating the legal phases of "meteor rights" with a view to claiming it if the law sustained her.

Mr. Christensen is merely a renter. In the meantime we had written the postmaster at Herman, asking for the names of persons who might be able to give us the story in detail. He suggested that we write Pete Christensen and Martin Enwalsen. Mr. Christensen replied directly and Mr. Enwalsen turned his letter over to Mr. Albert Hansen who sent us the facts in considerable detail, and samples of the formation found under the break in the power line.

It appears that Mr. Christensen saw, during a severe thunderstorm a ball of fire which appeared to fall from heaven, and that this was followed by flames apparently leaping higher than the power line. On going to the place later, a peculiar light stony formation was found beneath the break in the line. It was about fourteen inches long, four inches thick, five and a half pounds in weight, and was quite hot when found. He and others assumed naturally that this had fallen from heaven and cut the wire (one wire) which was down. Mr. Hansen wrote that he did not wish to question Mr. Christensen's honesty, but that he and Mr. Enwalsen believed the fire from heaven was lightning, which brought down the power line, and that the high voltage current shorted into the ground had formed the peculiar object found. The specimens showed Mr. Hansen was right, as persons familiar with fulgurites recognized them at a glance. When lightning strikes in sand dunes or sandy soil, the sand is fused into a tube, in some instances as long as thirty feet, the inside being light colored fused silicates and the outside dark. These formations, known as fulgurites, are sometimes exhibited in museums as "petrified lightning." A power line going down produces the same formation on a smaller scale, and in a mass rather than a long tube. Professor Wm. M. Young of the Electrical Engineering department of the University stated that he had seen a mass formed in that way, which in size and weight fitted very well the description of the large mass found at Herman.

Professor Young also suggested that the lightning probably did not break the power line directly. It is more probable that it shattered an insulator, which allowed one wire to swing too close to another. The discharge across the intervening space would have made a brilliant arc which might well have been taken for flames leaping higher than the poles, until one of the wires was melted through and dropped.

It is easy to understand how such an incident might start a meteor story, but this is the first time "petrified lightning" has been submitted to us as a supposed meteorite, and in this instance the actual sender assumed it was formed by electricity.

C. C. WYLIE.

University of Iowa, May 26, 1931.

COMET NOTES

By G. VAN BIESBROECK.

The lack of visible comets continues. None have been discovered for many months, neither new ones nor returns of expected periodic ones.

With powerful instruments COMET BEYER (1930*b*) can still be recorded photographically but it is gradually receding from the center of the Solar System and losing in light correspondingly. It has been followed continually since March of last year. E. C. Bower has computed the following continuation of the ephemeris,

EPHEMERIS OF COMET BEYER (1930*b*).

1931 0^h U.T.		α h m s	δ ° ′ ″	M
June	8	18 20 34.0	+39 23 12	14.9
	16	13 24.1	38 57 13	
	24	6 17.8	38 17 47	
July	2	17 59 30.9	37 25 42	
	10	53 16.6	36 22 10	15.1
	18	47 45.7	35 08 40	
	26	43 06.3	33 47 09	
Aug.	3	39 22.9	32 19 44	
	11	17 36 37.0	+30 48 23	15.4

According to the observations made by the writer on May 13 and 14, the correction of the ephemeris at that time was —8ˢ and +5′ and the brightness was about one magnitude fainter than the computed value. On the plates the comet appeared as a small round coma only 10″ in diameter. The ephemeris shows that the comet will be very well placed for northern observers during the summer but it soon will be too faint for the instruments now in use.

Two periodic comets come in reach of observers in June.

The first one is COMET ENCKE which might have been recovered already last winter; but its unfavorable position frustrated the attempts. Its nearest approach to the Sun occurs on June 4; however at that time it sets only $1^h\,20^m$ after the Sun. The following Ephemeris is from the *Handbook* for 1931 of the British Astronomical Association:

SEARCH EPHEMERIS FOR PERIODIC COMET ENCKE.

1931 0^h U.T.		α h m s	δ ° ′
June	4	6 1 20	+23 4
	8	6 27 12	20 50
	12	6 49 32	18 2
	16	7 8 26	14 51
	20	7 27 8	11 11
	24	7 47 12	6 48
	28	8 10 16	+ 1 30
July	2	8 38 24	— 5 4
	6	9 13 32	12 54
	10	9 58 24	21 43
	14	10 53 58	30 22
	18	11 57 26	37 7
	22	13 1 18	41 1
	26	13 57 40	42 30
July	30	14 43 22	—42 26

The rapid southerly motion will bring it well in view for southern observers, but at the same time keep it out of reach for northern stations.

The other periodic comet expected is NEUJMIN (1913 III). Its anticipated course can be seen from the accompaning ephemeris deduced from the elements

EPHEMERIS OF COMET NEUJMIN (1913 III).

1931 0^h U.T.		α h m s	δ ° ′	M
June	3	1 17 6	+ 9 2.8	14.1
	11	1 36 43	12 9.5	14.2
	19	1 55 53	15 7.5	14.3
	27	2 14 33	17 56.4	14.4
July	5	2 32 40	20 35.0	14.5
	13	2 50 9	23 3.4	14.6
	21	3 6 52	25 21.6	14.7
July	29	3 22 43	+27 30.2	14.8

computed by the writer (*A.J.*, **49**, 77, 1930), assuming 1931 March 9 as the time of the nearest approach to the Sun. The comet is a morning object rising two hours before the Sun at the beginning and five hours before the Sun at the end of the period covered by the ephemris. But it will be quite faint. H. E. Wood, Director of the Johannesburg Observatory, has already tried to pick up this comet during this spring when it was fairly well placed for southern observers but he reports no success so far on account of unfavorable observing conditions.

In order to clear up the doubt that remains concerning the moving object that K. Nakamura followed last fall from 1930 November 13 to November 18, at Kyoto (Japan) and that was not found by other observers immediately afterwards, the measures that he published in Bulletin No. 192 of the Kwasan Observatory have been discussed here numerically. The measures were first tested by a simple interpolation formula containing the time to the second power. This showed that all the positions fitted into a smooth curve with no deviations larger than 1ˢ in right ascension nor more than 0'.1 in declination. A solution for a general orbit based on the positions for November 13, 14, and 15 led to an inadmissable small distance. The same difficulty was encountered when the longer interval November 13, 16, and 18 was used. Next a parabolic orbit was deduced from the latter observations. This left a systematic run in the residuals amounting to 3' mainly in declination. When a differential correction of the elements was tried in order to remove this deviation, no reasonable solution could be found, showing that no motion following the laws of gravitation can represent the position. The conclusion that the measured images of the object have no physical reality seems therefore hard to avoid; at least several of these do not fit into any reasonable orbit.

Williams Bay, Wisconsin, May 22, 1931.

NOTES FROM AMATEURS

A Slow Motion for Amateur Telescopes

A simple type of slow motion which can be made by an amateur with a minimum of trouble and expense is described in this article and illustrated by the accompanying photographs. The fundamental principle is not new, being that of the ordinary tangent screw motion, but the present application of the idea to the gas-pipe mounting is original and was developed by Sterling Bunch of the Texas Observers. With a little ingenuity the idea should be easily adapted to the Ford axle and other types of home-made mountings.

The polar axis of the gas-pipe mounting consists of an outside or housing pipe and an inner revolving pipe working on bearings, which is the axis proper. To use the slow motion described here, the lower ends of both pipes must be threaded to take floor flanges. The inner revolving pipe should be longer than the housing by about two inches and should be threaded this entire distance. One flange screws on to the housing pipe and two screw on to the revolving pipe; these latter two will have to be specially reamed out to screw up the required distance.

A hole must be drilled through the housing flange and through one of the axis flanges, near the edges. The holes already in the flanges will not do as they are countersunk. Another hole must be drilled and tapped in the shoulder of the housing flange and a set screw inserted so that the flange can be fastened tightly on the housing in any desired position.

The cost of having the pipes threaded, two flanges reamed out and the three holes drilled, is practically all the machining expense the average amateur will meet and should cost about $2 or $3.

The other parts shown in the photographs (Fig. 1) are machined, with the exception of the long bolt and the guiding handle, but the sight of these machined parts should not be discouraging, because everyone of them can be replaced by parts made from stove bolts and taps with a little welding.

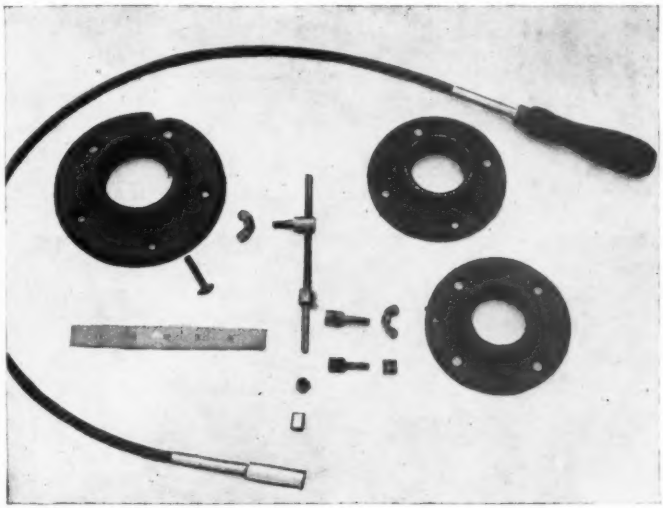


FIGURE 1.

The essential parts for the slow motion. The beheaded stove bolt with tap attached and extra tap is shown beside the machined post.

As Fig. 2 shows, one post fits through each of the holes in the flanges; and it may be remarked here that these holes should be just large enough to take the posts without binding, otherwise lost motion will be encountered later. The posts are held in place by wing nuts—not too tightly, as each post must pivot freely. Holes are drilled through both posts on the unthreaded ends at right angles to their length, and, in the case of the post working in the axis flange, the hole is tapped to take the threaded end of the long bolt. In the present slow motion the threads used were 20 to the inch ($\frac{1}{4}$-inch bolt). It should be remembered that the hole in the post in the housing flange should not be tapped.

For the slow motion worm a smooth shouldered bolt is preferable. After it has been beheaded, a collar is soldered on where the threads end, the post slipped on over the shoulder, and an additional collar soldered on the bolt behind the post. In this particular instance, the remainder of the shoulder protruding through the post was threaded to take two collars acting as lock nuts, so that the bolt could be adjusted to work in the post freely but without play.

The end of the flexible shaft is screwed, or otherwise fastened, on to the end of the bolt bearing the lock collars. This type of shaft works admirably on such a slow motion, and is sold by the Walker-Turner Co., Inc., of Jersey City, New Jersey, for $1.00. It is part of a motor driven polishing and buffing outfit and is obtainable at the W. T. Grant department stores. It is simpler and cheaper, but

not as convenient, to use a short piece of rod or tubing, driven into a wooden file handle at one end, and soldered at the other end to a small universal joint like those accompanying socket wrench sets sold by automotive supply houses. This universal joint must in turn be soldered or welded to the end of the slow motion bolt. In either case the object is to enable the observer to use the slow motion from any desired position of the eyepiece.

When the affair is complete, assembling the parts and attaching them to the pipes will seem a Chinese puzzle, but we assure you it can be solved. Fig. 2 is proof! Once all is together, as shown, turn both axis and housing flanges so that the handle end of the slow motion bolt is to the east or west, according to the observing position; then clamp the housing flange by tightening the set screw in its shoulder.

Next, run the bottom flange up against the top flange on the axis pipe and screw tight. It then acts as a lock nut, so that both of the axis flanges will rotate

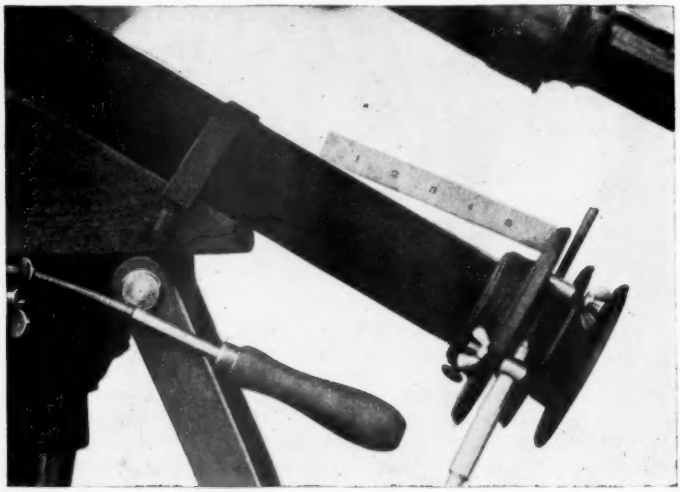


FIGURE 2.
The slow motion parts assembled and attached to butt of polar axis.

only with the entire shaft. The shoulder of the bottom flange may be roughened with a coarse file to make it grip. As the slow motion handle is turned, the bolt works through the posts in the flanges, and, since the collars on each side of the post in the housing flange keep the bolt in the same position relative to the housing flange, the effect will be to pull the other post around, together with the axis flange and the axis itself—a slow motion.

The 20 threads to the inch used in this case give a motion such that 10 turns of the handle are required for one hour of right ascension. Finer threads are preferable because they give a slower motion.

The posts and collars which the parts illustration shows are machined, but, as already mentioned, taps can be used as collars, reamed out if necessary, and posts can be made by welding taps on the ends of beheaded bolts—a shop job that will

cost about fifty cents. One such piece is shown in the picture just beside the part it replaces. The first form of this slow motion made by Bunch was constructed in this way, and, with a portrait lens mounted in a box, our "beloved Aberration Camera," and strapped on a 3½-inch guiding telescope, star photographs with exposures of an hour and more were made with successful guiding.

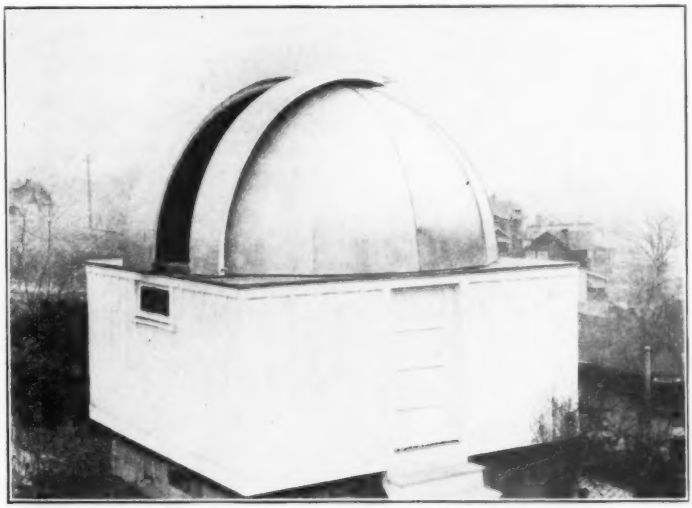
It should be remembered that the success of any slow motion depends in a large measure on the smoothness and ease with which it turns, and to insure this the bearings of the polar axis should be as smooth as possible and the counterweight system well adjusted. A little light machine oil on the moving parts of the axis and slow motion will be found helpful.

Our group, the Texas Observers, soon built a better mounting of the Ford axle type with a more elaborate slow motion. [See POPULAR ASTRONOMY, **38**, 317 (June-July). 1930.] This acquisition stopped further experimenting, but it is believed that the simple type of slow motion outlined here is sufficient to enable interested amateurs to do photographic work of reasonably good quality.

OSCAR E. MONNIG AND STERLING BUNCH.
312 West Leuda St., Ft. Worth, Texas, March 21, 1931.

Amateur Astronomers and Telescope Makers of Pittsburgh

The first Assembly of Amateur Astronomers and Telescope Makers of the Pittsburgh district will be conducted under the auspices of the Astronomical Section of the Academy of Science and Art, Saturday and Sunday, August 8-9, 1931.



VALLEY VIEW OBSERVATORY.

The program of activities includes a visit through the optical shops of John W. Fecker, successor to the John A. Brashear Company, makers of the world's greatest telescopes; here will be seen under construction a 69-inch reflector.

Through the courtesy of Dr. Frank C. Jordan, Director of the Allegheny Ob-

servatory, the use of their excellent 13-inch refractor will be granted the amateurs for the evening of August 8. In case of inclement weather, an illustrated lecture on Astronomy will be delivered.

Festivities will include a dinner outdoors in beautiful Riverview Park adjoining Allegheny Observatory, and will end Sunday, August 9, at Valley View Observatory, headquarters of our organization. This observatory here shown was recently built by the members.

Anyone interested in attending this gathering of enthusiasts can obtain further information by writing the Secretary of the Astronomical Section, Leo J. Scanlon, at the Valley View Observatory, 106 Van Buren St., Observatory P. O., Pittsburgh, Pennsylvania.

ZODIACAL LIGHT NOTES

By W. E. GLANVILLE.

Evening Zodiacal Light.—From Mr. Stuart L. O'Byrne, Chairman of the Astronomy Group, Nature-Study Society, Webster Groves, Missouri, reports with diagrams have been received of observations on April 17 and 18. On April 17 at 7:50 P.M., Mr. O'Byrne found the apex much confused with the Milky Way. "The south boundary was almost perpendicular to the horizon, passing through the northern part of the Hyades and just south of Beta Tauri. The north boundary was fairly well marked along a line through Zeta Persei and two or three degrees south of Iota Aurigae . . . On April 18 at 8:00 P.M., the boundaries of the Light were very indistinct although the bright central portion was considerably brighter than any visible part of the Milky Way. The area covered by the Light was less wide than on the previous evening; the south boundaries on both evenings were almost identical. The apex was observed to be farther east than on April 17; it was about six degrees east of Beta Tauri and very indistinct. The central line cut the horizon about two or three degrees south of the ecliptic." The writer observed the Light on April 12, 13, 18, 19, May 3, 4, 5, 8. On April 12 from 7:45 to 8:15 the apex could not be determined on account of its mingling with the Milky Way. The south boundary was indicated by Lambda Tauri, thence midway between the Hyades and the Pleiades to the apex. The north boundary passed more than midway between Alcyone and Zeta Persei, thence broadening to the horizon. From 9:10 to 9:20 the Hyades being nearer to the horizon than at 8:00 P.M. were covered by the Light which then extended northward about halfway between Zeta and Beta Persei. On April 13 a heavy cloud bank was on the horizon at 8:00 P.M. The south boundary skirted the Hyades group on the north and passed more directly to the cloud bank than the north boundary which was markedly diffuse. The Light was stronger between the Pleiades and the Milky Way than on the previous evening. On April 18, the sky being unusually clear, from 8:10 to 8:30 the south boundary passed Aldebaran straight-edged to the horizon; the diffuse north boundary extended from Beta Tauri, halfway between Zeta and Xi Persei, thence to the horizon. Breadth on horizon was about 25 degrees. The apex could not be outlined on account of the Milky Way. General appearance of the Light was that of a truncated cone. On April 19 at 8:00 P.M., it was interesting to watch the fading of normal twilight from Perseus to the ecliptic and from Orion to the ecliptic. Concurrently with the disappearance of normal twilight was the emergence of the Zodiacal Light at 8:15. General shape

and appearance of the Light were the same as last evening. The central line passed through the Pleiades. On May 3 the apex was made out between Jupiter and Pollux. Breadth along the horizon was about 30 degrees. On May 4 at the second observation at 10:25 hardly any trace of the Light was visible 10° beyond the horizon. It was fading out and notwithstanding the lower altitudes of Jupiter and Castor and Pollux the sky was perfectly dark in that area. It has been customary to say that the non-visibility of the Light (as in our clear, moonless summer nights) is due to the ecliptic coming low, but at this season of the year the contrary condition holds west of the meridian. On May 5 at 9:20 the apex appeared blunt slightly northwest of Jupiter. The south boundary was marked by Mu Geminorum, thence five degrees south of Zeta Tauri clearcut to the horizon. The north boundary was about 10° south of Capella. General note: As the season advances the altitude of the Light, say, one and one-half hours after sunset, becomes increasingly less and the spread of the Light along the horizon becomes increasingly greater.

GEGENSCHEIN.—On April 18 and May 5 the Gegenschein was observed. On April 18 it was seen a few degrees northeast of Spica, Lambda Virginis being within the luminosity which was faint, diffuse and slightly elongated. On May 5 it was glimpsed just east of Alpha Librae and extended about 12° towards the head of Scorpio. It was extremely faint with the shape of an elongated oval about three degrees in its widest part.

CHANGING APPEARANCE OF THE GEGENSCHEIN AS TO SIZE AND SHAPE.—The seasonal changes as observed in temperate latitudes are probably due to perspective, depending on the slope of the ecliptic. When one looks squarely at the Gegenschein it is round and largest. When one views it on the slant of the ecliptic it is elongated. Hence, at the equinoxes when one sees it in full front view it attains maximum rounded appearance, especially at the autumn equinox when, as Professor Barnard remarked, "It fairly stares you in the face." At the vernal equinox, when the ecliptic intersects the equator in a southerly direction, the size of the Gegenschein, while well rounded, is less than at the autumn equinox.

The Rectory, New Market, Maryland.

GENERAL NOTES

The next issue of POPULAR ASTRONOMY, as our regular readers will remember, will be a joint issue for August and September and will be mailed about August 1.

Dr. W. W. Campbell, President Emeritus of the University of California and Director Emeritus of the Lick Observatory, has been elected President of the National Academy of Sciences.

Dr. R. G. Aitken, Director of Lick Observatory, gave a lecture in the auditorium of the new Chemical Building of Ohio State University on April 22, under the auspices of its Graduate School and of the Perkins Observatory of Ohio Wesleyan University. The subject of his lecture was "Recent Progress in Astronomy."

Professor Charles Lane Poor has been obliged by reason of ill health to resign from his duties in connection with the Department of Astronomy in Columbia University, the resignation to take effect on June 30. Professor Poor hopes, however, to be able to continue his work along scientific lines.

Dr. Harlan T. Stetson, Director of Perkins Observatory and Professor of Astronomy at Ohio Wesleyan University, gave a lecture on April 24 on "Astronomy and Electricity" before a joint meeting of the New York Section of the Institute of Electrical Engineers and the New York Electrical Society. The lecture was givn in the Engineering Auditorium.

Dr. W. J. Luyten, formerly of Harvard University came to the University of Minnesota at the beginning of the spring quarter to re-open the department of astronomy which had been discontinued during the past two quarters.

Dr. Luyten, a native of Holland, is now an American citizen. He has a doctorate from the University of Leiden.

Professor A. A. Ivanoff retired at the end of December, 1930, from the position of Director of the Observatory in Pulkovo and assumed the office of the President-Adjoint of the Central Chamber of Weights and Measures, Leningrad.

Sir James H. Jeans was the guest of honor at a dinner at the Hotel Astor, New York City, on May 28, given under the auspices of The New York Museum of Science and Industry, The American Institute, The American Museum of Natural History, The Amateur Astronomers Association, the New York Academy of Sciences, and *The Scientific Monthly*. Professor Michael I. Pupin presided and Sir James spoke on modern theories of the universe.

Professor Jan Schilt, of Yale University Observatory, has been appointed head of the Department of Astronomy at Columbia. He will take up his duties there about October 1.

Columbia Observatory has recently put up a fine 12-inch telescope, principally for the use of students. It is not the intention of the University or of the new Director to aim for the acquisition of a larger telescope; it is planned instead to reorganize the department on the basis of a statistical bureau especially for the discussion and correlation of stellar characteristics.

Mr. and Mrs. David B. Pickering were guests of honor at a dinner held at the Chabot Observatory on Saturday, May 23. After the dinner Mr. Pickering addressed the East Bay Astronomical Association on the subject, "The Romance of the Variable Stars." Mr. and Mrs. Pickering will sail on June 11 for Honolulu and Japan. They will return to this country in the latter part of the summer.

The Reverend C. D. P. Davies, a member of the Royal Astronomical Society since 1889 and an amateur who made real contributions to the science of astronomy, died at his home near Tewkesbury on February 5, 1931, in the seventy-fifth year of his age. Campanology like astronomy had interested him greatly.

Three Astronomers were among the twenty-seven persons recently elected to membership in The American Philosophical Society at its meeting in Philadelphia in April. They are Raymond Smith Dugan, professor of astronomy, Prince-

ton University; Carl Otto Lampland, astronomer, Flagstaff, Arizona; Sir Arthur Stanley Eddington, professor of astronomy, Cambridge University, England.

Professor Raoul Gautier, who was for many years Director of the Geneva Observatory, Switzerland, died on April 19 at Geneva. He was Vice-President of the International Geodetic and Geophysical Union. He is known to astronomers chiefly for his interest in variations of latitude. During the war, when the International Geodetic Association necessarily ceased operating, Professor Gautier was largely instrumental in forming what was called the Reduced Association among Neutral States, and was its President for several years thereafter; and it was in this way that what would have been a very serious break in the observations was avoided. Professor Gautier was for many years President of the Swiss Geodetic Commission. He was a man of unusually wide attainments and unusually charming personality.

The Paris Observatory, according to information contained in *Nature* for April 18, 1931, is to be closed so far as actual astronomical work is concerned. This is a consequence of a decision to erect a new national observatory at a cost of approximately two million dollars in the Durance region of Provence. The old building in Paris will be retained as a repository for equipment not in use and the many historic instruments the observatory possesses.

Astronomical work at the Paris Observatory was begun by Cassini in 1671 and has been continued without interruption until the present time. As frequently happens, the city has enveloped the observatory to such an extent so as to make conditions unsuited for observational purposes.

In a sense the long period of astronomical work of this important institution will be continued but in a new location.

Steward Observatory Fellowship.—A fellowship paying $600 per academic year has been established for graduate study at the Steward Observatory of the University of Arizona, Tucson. A portion of the incumbent's time will be required for services to the Observatory (not ordinarily in connection with teaching), but time spent with the 36-inch reflector upon the fellow's problem of investigation may be counted very largely towards this. Graduate studies may lead to the master's degree. It is not planned at present to offer the doctorate. Application should be made to Professor A. E. Douglass, Director, and should be accompanied by a copy of the applicant's academic record and the names of at least three persons able to testify as to the applicant's qualifications.

A Note on Determination of Leap Years

In view of the approaching International Conference on Calendar Simplification it seems worth while to suggest a more rational method for determining the occurrence of leap years than that now in use.

The tropical, or common, year contains $365^d\ 5^h\ 48^m\ 45^s.98$, or 365.24219879 mean solar days. This is an excess over the even 365 days per year of 31 days plus 125 seconds in a period of 128 years. Hence, if all years whose numbers are divisible by 4 are leap years except those whose numbers are divisible by 128, the error involved amounts to less than one second per year, or a total of 31.4 minutes since the beginning of the Christian era. To allow for this small discrepancy we may specify that once in every 88,576 years the 128th year shall be a leap year.

According to the Gregorian calendar the year 2100, although divisible by 4, will not be a leap year. Under the above-mentioned arrangement the first year divisible by 4 but not a leap year would be 2048.

A. E. Caswell.

University of Oregon, Eugene, Oregon.

Planetary Progression

While working with a slide rule recently, the writer noticed that the ratio between the solar distances of two successive planets is in most cases quite close to one-half the Napierian base or to the square of this fraction. The ratio was later found to be more nearly exact if some fractional part of the eccentricity of the orbits was used in the scheme.

If we raise the base $\frac{1}{2}(e + E)$, where E is the eccentricity of the orbit of the planet under consideration, to various powers, we get a series of numbers which are very close to the planetary distances from the sun. If these are reduced to astronomical units, the error is less than one per cent in all but three cases. If the numbers are multiplied by the secants of the inclinations of the orbital planes to the plane of the sun's equator, the errors are still smaller. By increasing E by the small constant, 0.00135, almost exact results are obtained in the majority of cases. This constant is the mass of the planetary system (as known at present) in terms of the mass of the sun. This likely has no significance, however, in this connection. E in the calculation below stands for the eccentricity increased by this constant. The final form of the base is $\frac{1}{2}(e + aE)$. a is 1 in all cases excepting where the orbital eccentricity is quite high (more than one-tenth of the base). Then it is 0. This base is represented by k in the discussion which follows. The formula then becomes $k^n \sec i$.

The computations used give n the values 0, 2, 3, 4, 6, 8, 10, 12, 14, and 15, for the major planets and the asteroid space. If, however, Mercury, Venus, the earth, and Mars are given 1, 3, 4, and 5 for the values of n, the results are still quite accurate. Trouble is encountered with the more distant planets unless n is given the value 0 in the case of Mercury.

The following table shows the results of the calculations:

Planet	Indicated Operation	Result	Computed A.U.	Accepted A.U.	Percent of error
Mercury	$k^0 \sec 3° 13'$	1.0016	.3880	.3871	0.23
Venus	$k^2 \sec 3° 48'$	1.8624	.7215	.7233	0.25
Earth	$k^3 \sec 7° 11'$	2.5815	1.000	1.000	0.00
Mars	$k^4 \sec 5° 33'$	3.9319	1.523	1.524	0.07
Asteroids	k^6	.....	.....	.....	....
Jupiter	$k^8 \sec 6° 2'$	13.537	5.244	5.203	0.79
Saturn	$k^{10} \sec 5° 30'$	26.605	10.31	9.539	8.09
Uranus	$k^{12} \sec 6° 25'$	49.446	19.15	19.19	0.21
Neptune	$k^{14} \sec 6° 23'$	77.732	30.11	30.07	0.13
Pluto	$k^{15} \sec 12° 2'$	101.95	39.49	39.46	0.08

It will be noticed that Saturn does not seem to fit into this scheme very well. It will fit as well as most of the others if $k^{9.8}$ is used instead of k^{10}, or if 0.3 of the eccentricity is used instead of 0.5. The numbers under "Result" above are Mercurian Units. These are divided by 2.5815 to obtain the numbers in the next column. The true Mercurian distance of the earth is 2.5833.

That the use of the proper eccentricity is in most cases very essential is easily shown by using wrong values in the formula. If the value for the earth is applied to Mars, and the values for Uranus and Neptune are exchanged, the per-

centages of error become approximately 10.0, 16.0, and 21.0 instead of the small amounts in the table above.

With slight variations, this law works excellently for the four larger moons of Jupiter, and for all the moons of Mars and Uranus. Nothing satisfactory has been worked out for the satellites of Saturn. They seem to be as hard to bring under this law as their primary. Since the value of sec i is too small to make any marked difference in the results, it is omitted in the formulas for the moons of the planets. So is the addition to the eccentricities of a small constant. If it does represent the satellite mass in terms of the primary, it would be insignificant here. In the following table the base for the system of Jupiter is $(e/2)^{\frac{1}{2}} + 2E$. If, in the formula, $e/2$ is used, instead of its square root, the values of n must be approximately 0, 1.5, 3.0, and 4.5. For the system of Uranus, the base is $(e/2)^{1/3} + E$. For Mars, which is too small a system to prove much, $e/2 + E/4$ is the base. The first satellite is taken as the standard in each case.

	Moon	Calculated Ratio	Actual Ratio	Percent of error
Jupiter	No. 1	$k^0 = 1.000$	1.000	0.00
	No. 2	$k^3 = 1.587$	1.591	0.25
	No. 3	$k^6 = 2.549$	2.537	0.47
	No. 4	$k^9 = 4.463$	4.465	0.04
Uranus	No. 1	$k^3 = 1.385$	1.385	0.00
	No. 2	$k^6 = 1.929$	1.929	0.00
	No. 3	$k^{11} = 3.152$	3.166	0.44
	No. 4	$k^{14} = 4.240$	4.233	0.16
Mars	No. 1	$k^3 = 2.534$	2.534	0.00
	No. 2	$k^6 = 6.325$	6.341	0.25

Surely the excellent arrangement of powers and the small errors in the above tables are more than accidental. It is not claimed that the exact law has been stated (if there is one) but it seems to the writer that it must depend in some way on the quantities used here. Many other excellent schemes have been proposed recently, but the common per cent of error comes out more than one. Below is a table comparing Bode's law, Harvey's radii law (Pop. Astr., May, 1930), Spahr's triangle law (Pop. Astr., Aug.-Sept., 1930), Ericksen's logarithm law (Pop. Astr., Nov., 1930), and the Dufton-Caswell law of squares (*Science*, n.s. 69: 384, 1929). The figures given are the percentages of error. This seems to be the easiest way to compare them at a glance.

	Bode's	Harvey's	Spahr's	Ericksen's	Dufton-Caswell's
Mercury	3.4	1.3	1.3	2.3	1.5
Venus	3.2	3.2	14.5	14.9	6.2
Earth	0.0	0.0	0.0	0.0	5.6
Mars	5.2	7.4	6.2	6.7	0.2
Jupiter	0.1	2.1	18.5	17.4	1.4
Saturn	4.8	1.6	16.3	19.0	0.0
Uranus	2.1	4.3	6.5	3.9	2.7
Neptune	...	2.3	3.5	0.3	2.7
Pluto	1.7	...	19.0	23.5	2.8

J. Hugh Pruett.

P. O. Box 185, Eugene, Oregon, April 21, 1931.

A Review in Astronomy

Most persons feel that there are many questions which might be asked about astronomy. The subject is so vast and, unless one has approached the field in a systematic and careful manner, the entire subject seems to be one great question. Mr. F. D. Tubbs, 809 West California Ave., Urbana, Illinois, has submitted a list of thought-provoking questions, the answers to which do not lie too deeply hidden.

Here are a few of them. Anyone wishing to formulate answers to these questions is encouraged to do so. The answers will be given careful consideration and corrected, if necessary, and returned, if they are sent either to the editor or to the proposer mentioned above.

1. Why is a star never where it appears to be at a given moment? Give more than one reason. Is the same fact true of the other heavenly bodies?
2. How often would the Earth rise and set if the observer were on the lunar "crater" Copernicus? If at the antipodes of Copernicus? Where must one be on the Moon to see the Earth rise and set?
3. If on a day in July the Sun rises 20° N. of East, where will it set?
4. Why does the hottest weather come later than the longest day?
5. Why do tides,—at least tidal strains,—differ in amount on different suns and worlds? Give at least four reasons.
6. What is the time of day and the date on each side of the International Date Line, right now?
7. Why did Dante call the Sun a planet? Name the other six planets known in Ancient and Medieval Times? Compare the names of the days of the week.
8. Have you seen earth-shine? Have you seen the Earth shine? Could you see earth or anything else unless it were shining?
9. In which direction does daylight travel over the Earth? Over Mars? Over the Moon?
10. When the Pole Star is clouded, but the Big Dipper visible, how could you find north? How can you find directions by the aid of the Moon? Of the Sun?
11. With the help of a compass how can you tell the time of day by the Sun? By the Moon?
12. Is there more moonlight in winter or in summer?
13. What are the proofs that stars are comparable to the Sun in size?
14. Give several reasons why stars differ in brilliancy (a) in and of themselves; (b) as seen from the Earth.

BOOK REVIEWS

Astronomy: A pamphlet of ninety pages, bearing this name, has recently been prepared by Robert I. Wolff and published by The Beacon Press, Inc., New York City. It is designed to take its place among similar pamphlets as the basis for a Science Survey course which is being given at the College of the City of New York. It is divided into five chapters, which treat, more or less in the conventional manner, the well established essentials of this science. Numerous figures are scattered throughout the pamphlet, many of them well chosen for the purpose of illustrating the points under discussion. A reading of this work will give one a good introduction into classical as well as modern astronomy.

Atlas Celeste, by E. Delporte. Cambridge: at the University Press: New York: The Macmillan Company.) This is a companion volume to "Delimitation Scientifique des Constellations," which was described on page 182 (March). It contains the same charts as the former work, and in addition, on the page facing the chart, in each case are listed the principal stars with their magnitude, spectrum, and position for 1875 and for 1925. Also the objects of special interest, such as variable stars, double stars, clusters, and nebulae, which are within the particular chart are listed. This adds much to the usefulness and convenience of the charts.

A Catalogue of the Harvard Observatory Meteor Photographs has recently been published as Volume 87, Part 3, of the Astronomical Observatory of Harvard College. This catalogue was prepared by Willard J. Fisher and Margaret Olmsted, and contains descriptions of 386 plates on which meteor trails have been

found. As a rule these plates were made primarily for some other purpose, and the meteor trail is incidental. However, an effort was made to photograph the Leonids in 1898 and in 1901 with a fair degree of success. Considerable detail concerning each trail is given, making this an interesting and useful contribution.

Catalogo Generale di Parallassi Stellari is the title of a large sized volume of one hundred fifty pages, by Gino Cecchini, published in 1931 by Ulrico Hoepli, Milan. This is the first part of the researches of the author on the frequency of the absolute magnitudes of stars of the several spectral classes. This volume contains an extensive inter-comparison of the trigonometric parallaxes obtained at the several observatories engaged in this work. A catalog of 3975 stars whose parallaxes have been determined, by trigonometric or some other method, collected from thirty-eight sources is included. It is certainly a very useful volume to have at hand for various lines of astronomical study.

Astronomy Made Easy is the title of a pamphlet of 116 pages recently issued by Rand McNally and Co., intended primarily for use with a new Celestial Globe and Star Finder, prepared by the same publishers. The globe is eight inches in diameter and may be had in several types of mounting ranging in price from $12 to $30. This globe is designed to make clear many of the questions which are puzzling to the beginner, and also to serve as a device for securing quickly approximate information by the trained astronomer. Problems arising from air navigation are readily solved by the use of it. The pamphlet mentioned above is much more than a mere hand-book of instructions for the sphere. It contains many summaries of astronomical facts, and a careful reading of it would lead to a rather comprehensive grasp of the classical information relative to the earth and the sky. Numerous diagrams are used to illustrate the discussions, and the pamphlet is worthy of reading by anyone who has the least spark of curiosity about the world in which he lives.

The Mysterious Universe, by Sir James Jeans. (The Macmillan Company, New York. Price $2.25.)

This book has already had wide circulation and wide reading on both sides of the Atlantic. The writer is one of those whose names have become familiar to all intelligent readers of the English language the world over. On taking up this book of 160 pages one might reasonably expect to read it in a few hours. However, one finds that it is not the kind which can be read by pages but must be read carefully by sentences. The reviewer may be below the average reader in intelligence but, waiving that possibility, his experience prompts him to recommend a second reading even though the first reading may have been done very carefully. However, the reader will be amply repaid for this extra effort. He will have been brought into close contact with the most recent thought in science and in philosophy. One would need to search far and wide to find a book more stimulating to the intellect and the imagination.

Les Observatoires Astronomiques at les Astronomes, issued by the Observatory at Uccle, Belgium. (Price 14 Belgian Francs, or 10 Swiss Francs.)

This volume of 314 pages is a compendium of very useful information for astronomers the world over. Because of the regular international meetings of astronomers the work in this science has become to a large extent a coöperative enterprise. Consequently two persons may be working on the same problem side by side or on opposite sides of the earth. This volume is sort of a telephone di-

rectory of the world for astronomers. It contains a very comprehensive list of observatories with the personnel of each; a list of the astronomical societies of the world, arranged chronologically as to their founding; a list of astronomical publications, alphabetically arranged, forty-six in number; and an alphabetical list of the names of all living astronomers, with the names of certain of the observatories interspersed.

This compilation will surely be welcomed by all astronomers. Those who collected and compiled the data are entitled to the gratitude of the entire profession for their labors.

A Beginner's Star Book (An Easy Guide to the Stars and to the Astronomical Uses of the Opera Glass, the Field Glass, and the Telescope), by Kelvin McKready. (Third Edition, 156 pages, 70 illustrations. G. P. Putnam's Sons, 1929. $5:00.)

The general reader or the beginning observer who would bring himself face to face with the friendly realities of the heavens will find this useful guide book a great help. Without intruding into the field of theoretical astronomy, one is led directly into enjoying the rich pleasures which observing gives. Mr. McKready, in a delightful fashion, introduces the reader to constellations and planets, nebulae and clusters, by recalling his own early observational experiences.

In glancing the book through, the reviewer was immediately impressed not only with the exquisite bookmanship, but with the care and accuracy with which the plates and charts had been assembled. The observer is at a distinct advantage if he possesses this book, for one of the features is its charts: On the right hand page of each opening in the star map section, the observer is provided with a "Key Map," together with a rather complete description of the interesting features of the sky in the region for which the map is intended; while on the left hand page, a so-called "Night Chart" appears, which treats the same portion of the sky as the Key Map, only having the names of the constellations, letters, and relating lines omitted, thus showing the region exactly as it appears in the sky. This worthwhile feature aids the lay observer, for he is usually troubled with trying to relate the uncharted sky with his map, which is already overcrowded with letters, lines, and symbols. Thus by easy deliberate stages, one may progress from his Sky Map to his Night Chart, and finally from his Night Chart to the actual sky, with much of the confusion resulting from not having such an intermediate step obviated.

Chapters entitled "Objects to be Seen" and "Some Instruments of Observation" follow in order, presenting the reader with a wealth of interesting information on what to see and where to look, and numerous valuable suggestions on how to purchase and use a field glass or a small telescope. The remainder of the book is devoted to "An Observer's Catalog" of interesting objects in the stellar world, giving the interesting objects of observation, together with useful facts concerning motions, magnitudes, spectra, etc., for each of the constellations arranged alphabetically.

A smaller and more compact edition of the same book is also available, entitled "A Beginner's Guide to the Stars." Selling for one dollar, this book, excluding some of the more elaborate features of the larger one, retains the Key Maps, and Night Charts, and information for their use. Fitting snugly into the pocket, this smaller edition forms a handy guide for the camper or scout.

The library of an amateur observer is incomplete unless one or both of these useful books appear on its shelves. W.M.W.